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THE ECOLOGY OF HELMINTHS IN BREEDING POPULATIONS OF LESSER SCAUP (*AYTHYA AFFINIS* EYTON) AND RUDDY DUCKS (*OXYURA JAMAICENSIS* GMELIN).

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled The Ecology of Helminths in Breeding Populations of Lesser Scaup (*Aythya affinis* Eyton) and Ruddy Ducks (*Oxyura jamaicensis* Gmelin) submitted by Lane Colin Graham in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

The helminths of 216 lesser scaup (Aythya affinis) and 96 ruddy ducks (Oxyura jamaicensis), mostly from Cooking and Hastings Lakes (east of Edmonton, Alberta), were investigated to determine the roles of these hosts in the circulation of helminths in these two lakes, and to elucidate some of the ecological factors involved in the population dynamics of their helminths.

A total of 46 species of helminths, including 13 trematodes, 24 cestodes, 6 nematodes, 2 acanthocephalans, and 1 leech, were recovered. Of these, 33 were new host records and 11 were new North American records.

Lesser scaup were main hosts of 13 species of helminths, auxiliary hosts of 17, accidental hosts of 9, and inhibitory hosts of 3 species. Ruddy ducks were main hosts of 6 species, auxiliary hosts of 11, accidental hosts of 4, and inhibitory hosts of 3 species. Scaup, and to a lesser extent ruddies, are responsible for a major portion of the pool of infective stages for a large number of helminths found in the water birds of these lakes.

No correlation between the helminth fauna and the sex or general condition of the host was found. Two scaup in poor condition had larger numbers of helminths as well as a more diverse helminth fauna, which appeared to be the result, not the cause, of the condition. There were no differences in helminth faunas between years or between the two lakes studied.

Immature scaup acquired helminths quickly, with the most common forms being acquired first. Adult scaup had a more diverse helminth fauna than immatures, due to the absence of accidentals, winter ground and early season forms from the immatures.

Gammarids were the predominant animal food taken by scaup, chironomids the predominant animal food of ruddies. This difference resulted in major differences in helminth populations.

Seasonal food habits, the summer turnover in the gammarid population, competition between Lateriporus skrjabini and Fimbriaria fasciolaris, and whether the helminths overwintered on the breeding ground or were brought in by the migrating birds were factors which produced differences in the seasonal abundance of helminths.

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INTRODUCTION

There has been little work on the circulation of helminths within any community. Wiśniewski (1958) summarized extensive ecological investigations into the parasitofauna of a eutrophic lake (Drużno Lake, Poland). More extensive reports on some individual parts of this study have been published by Jarecka (1958, metacestodes in planktonic crustaceans), Rybicka (1958, the tapeworms of birds excluding the Anseriformes), Styczyńska (1958, the Acanthocephala), and Sulgostowska (1958, the flukes of birds). Wiśniewski also includes information from other studies on the general limnology, ornithology, ichthyology and botany of Drużno Lake.

A similar long term study of the circulation of helminths in various aquatic habitats in the Edmonton area has been underway at the University of Alberta since 1961. The main sampling areas for the study have been Cooking and Hastings Lakes, located 35 miles east of Edmonton, Alberta. Cooking Lake is a highly productive eutrophic lake with a surface area of 35.12 km^2, and a maximum depth of 3.5 meters. The frequent winds prevent thermal stratification in such a shallow lake. The dissolved oxygen is depleted during the winter, therefore Cooking Lake cannot support a stable fish population, although it may be invaded in summer by the brook stickleback (*Eucalia inconstans*). Chironomid larvae and amphipods (especially *Gammarus lacustris* Sars, the biology of which has been investigated by Menon, 1966) are the dominant larger invertebrates. Other invertebrates, particularly cladocerans, ostracods, copepods, leeches, oligochaetes, and insects are also common in the lake. Hastings Lake is smaller and somewhat deeper (maximum, 7.5 meters) than Cooking Lake, and supports a stable fish population of yellow perch (*Perca flavescens*), northern pike (*Esox lucius*), and brook sticklebacks. The invertebrate

fauna is similar to that found in Cooking Lake. The limnology of these two lakes has been studied by Kerekes (1965).

These two lakes support breeding populations of a variety of water birds. In addition, they are important resting areas for large congregations of other migratory water birds. Although this avifauna was not investigated quantitatively, eared grebes (Podiceps caspicus), lesser scaup (Aythya affinis), coots (Fulica americana), ruddy ducks (Oxyura jamaicensis), and white-winged scoters (Melanitta deglandi) were abundant throughout the summer, and were accompanied by smaller numbers of many other water birds.

In connection with the long term study of the parasite fauna of these lakes, investigations on the ecology of the helminth of grebes (Gallimore, 1964) and coots (Colbo, 1965) have been completed and studies on Gammarus lacustris as an intermediate host (by M. Denny), the helminths of blackbirds (by J. W. Wolford), and the helminths of amphibians (by M. Z. Hameed) are under way. At the start of this study, in 1964, the parasites of the common anatids on these lakes had not yet been investigated. Therefore, this study was designed to determine the roles of the two most abundant species of ducks, lesser scaup and ruddy ducks, in the circulation of the helminths in Cooking and Hastings Lakes, and to elucidate the ecological factors involved in the population dynamics of their helminths.

The helminths of anatids are many (see the catalogue by MacDonald, 1965b) and extensively studied (see the bibliography by MacDonald, 1965a). MacDonald (1965b) lists the helminths recorded from anatids, and reviews the life histories, hosts, geographic distributions, frequency of record, and importance as a cause of pathology of each species. MacDonald's nomenclature has been adopted for all groups except the tritesticular Hymenolepididae, for which I have adopted the nomenclature of

Czapliński (1956), accepting the genera _Dicranotaenia_ Railliet, 1892; _Drepanidotaenia_ Railliet, 1892; _Echinocotyle_ Blanchard, 1891; _Cloacotaenia_ Wolffhügel, 1938; _Sobolevicanthus_ Spassky and Spasskaya, 1954; and _Hymenosphenacanthus_ Lopez-Neyra, 1958. All the other tritesticular hymenolepids are referred to the genus _Hymenolepis_ Weinland, 1858.

Rohde (1964) has pointed out that a simple listing of the hosts of a given helminth lumps frequently parasitized hosts with rarely-parasitized hosts and those in which the parasite does not mature. Systems of host-specificity which recognize one or both of these differences have been proposed by Sulgostowska (1958), Michajłow (1959), Dogiel (1964), and Gallimore (1964). I have used the host categories of Gallimore (1964):

Main Hosts:	hosts in which the intensity and extensity of occurrence are high.
Auxiliary Hosts:	hosts invaded less frequently and by a smaller number of helminths.
Accidental Hosts:	hosts invaded on rare occasions by few helminths.
Inhibitory Hosts:	hosts in which the helminths do not mature.

Discussions on the advantages and disadvantages of this system are found in Gallimore (1964) and Colbo (1965).

A variety of factors can be expected to affect helminth populations. Host sex, age, food habits and condition, habitat, year to year variation, and seasonal variation are examples.

The effects of sex of the host on helminth populations have received little attention by other workers, although specific behavior of one or both sexes could be expected to play an important role in the abundance of certain helminths. Male scaup congregate to molt, as do males of other members of the Aythyini, in the comparative safety of open water (Hochbaum, 1944). Molting male canvasbacks, congregating in open water and feeding on plant

material, had few helminths relative to females (Cornwell and Cowan, 1963). On the other hand, Colbo (1965) found no significant difference between the helminth populations of male and female coots, which do not show major behavioral differences which might affect helminth populations. A similar situation might be expected in ruddy ducks, which show strong pair bonds, the males remaining with the females throughout the season and assisting in the care of the young (Delacour and Mayr, 1945).

The effects of age on the helminth fauna have been investigated in various groups of birds by numerous authors. In general, immature birds have a higher intensity of infection than do adult birds (Ginetsinskaya, 1952; Bychovskaya-Pavlovskaya, 1962; Cornwell and Cowan, 1963; Buscher, 1965, 1966; and Colbo, 1965). Colbo (1965) suggested that the higher intensity in young birds probably reflects a lower resistance to infection Gallimore (1964), however, found little difference in intensity of infection between immature and adult grebes.

Many workers have considered the rate and order of acquisition of helminths by young birds. Ginetsinskaya (1952) stated that specific parasites predominate in young European coots. From this it would be expected that the helminths for which the bird is a main host and which occur at the highest extensity would be acquired early. Gallimore (1964) found this to be generally true in grebes. Bychovskaya-Pavlovskaya (1962) stated that, in general, cestodes are acquired first, followed by acanthocephalans, nematodes and, lastly, trematodes. Cornwell and Cowan (1963), on the other hand, found that trematodes and cestodes were the first to appear in young canvasbacks.

Bychovskaya-Pavlovskaya (1962) has also pointed out that adults generally have a more diverse trematode fauna than do young birds.

Attempts to correlate the condition of the host with the numbers

of its parasites have generally been made to implicate the parasites as disease agents. For example, Cornwell and Cowan (1963), used the emaciation index (E.I.) to compare the helminth populations of diseased versus normal ducks. They found that diseased birds, those with a markedly reduced E.I., had up to four times as many helminths and seven times as many trematodes as those considered normal. Bezubik (1956) suggested that the poor condition of several ducks he examined was due to heavy populations of a variety of helminths. On the other hand, Colbo (1965) found no case of a markedly reduced E.I. and no correlation between the E.I. and the number of helminths in coots.

Dogiel (1964) has reviewed the year to year variation in the helminth fauna of various groups of vertebrates. Most of his examples were associated with the affects of moist or dry seasons on specific parasites. Kisielewska (1961, 1964) showed that the cestode fauna of shrews was relatively constant from year to year, but that an exceptionally wet year did alter the fauna quantitatively. Colbo (1965) found a similar change in helminths of coots between a dry and wet year. A shift in coot populations from small sloughs to larger lakes produced a change in helminth populations typified by a decrease in those species characteristic of the slough habitat.

Differences in the parasite fauna of water birds from different habitats within the same general climatic region have been shown by many authors (Bychovskaya-Pavlovskaya, 1962; Sulgostowska, 1963; Korpaczewska, 1963; Cornwell and Cowan, 1963; Gallimore, 1964; and Colbo, 1965). Several reasons for these differences have been suggested. Populations of definitive hosts may differ on different lakes, and Sulgostowska (1963) suggested that the trematode fauna of a given lake most resembled the trematode fauna of the most common definitive hosts found there. In addition, even

closely associated lakes such as Cooking and Hastings Lakes may show significant limnological variations affecting the populations of intermediate hosts (Kerekes, 1965). Colbo (1965) found consistent differences in the helminth populations in coots from Cooking and Hastings Lakes which he attempted to explain on the basis of the size and continuity of the habitat suitable for coots.

Seasonal variations in the populations of helminths of water birds have received considerable attention in recent years. Earlier authors (Gower, 1938; Bezubik, 1956; and Okorokov, 1957) were content to lump different species of birds and/or different parasites assuming no specificity and similar seasonal variations within major groups of parasites, giving false pictures of seasonal dynamics. More recent workers, such as Bychovskaya-Pavlovskaya (1962), Sulgostowska (1963), Gallimore (1964), Buscher (1965), and Colbo (1965), have given more accurate pictures of these seasonal variations.

Colbo (1965) described five basic patterns of seasonal variation:

Spring peak:	high extensity in spring dropping during the summer.
Spring-fall peak:	high extensity in spring and fall with a lower extensity in mid-summer.
Summer peak:	low extensity in spring and fall with a higher extensity in the summer.
Fall peak:	gradually increasing extensity reaching a maximum in the fall.
Irregular:	no general trends of infection obvious.

Colbo, and Buscher (1965), independently concluded that a complex of factors, including the seasonal abundance of the intermediate host, the period of

larval development, and seasonal changes in food habits, combined to produce seasonal fluctuations in helminth populations.

Several Soviet workers (summarized in Dogiel, 1964) and Buscher (1965) have considered the effects of the migrations of waterfowl on their parasite faunas. This important aspect of parasite ecology was not investigated in this study.

Many workers (e.g. Bezubik, 1956; Jarecka, 1958; Bychovskaya-Pavlovskaya, 1962; Cornwell and Cowan, 1963; Ryšavy, 1964; Gallimore, 1964; Buscher, 1965; and Colbo, 1965) have concluded that the most important single factor in the determination of a bird's helminth fauna is the bird's food habits. Lesser scaup are omnivorous, but feed predominantly on animal matter. Fifty-four percent of breeding lesser scaup investigated in Manitoba had fed on gammarids (Rogers and Korschgen, 1966). Ruddy ducks are mainly herbivorous, but also feed on bottom invertebrates such as chironomids (Cottam, 1939). These differences in food habits should be reflected by differences in their helminth faunas.

MATERIALS AND METHODS

A total of 216 lesser scaup and 96 ruddies were collected in the Edmonton area from April of 1964 to October of 1965. Data on the locality and date of collection of these birds are summarized in Table I. All birds were shot, cooled as quickly as possible and returned to the laboratory, where they were examined immediately or frozen and examined when time permitted. Conventional methods of examination were used.

The emaciation index (E.I.) described by Cornwell and Cowan (1963) was used as a measure of condition. The depth of the keel was measured 2 cm from its anterior end, and divided into the depth of muscle 1 cm to the left of that point.

Four species of tapeworms (Hymenolepis abortiva, H. jaegerskioeldi, H. tuvensis, and H. parvula) were very small and often found in very large numbers. Absolute counts of these tapeworms were impracticable, therefore the numbers of each species were estimated by counting the worms in 10 or 20 ml aliquots of intestinal contents made up to 600 ml with water.

Trematodes were relaxed in cold water, fixed in A.F.A., stained in acetic acid-hematoxylin (Chubb, 1962) or acetocarmine, and mounted in balsam. Cestodes were relaxed and fixed as above, stained in Ehrlich's hematoxylin or Chubb's (1962) acetic acid modification of Horen's trichrome; and mounted in balsam. A regressive variation of the acetic acid-hematoxylin method (Chubb, 1962) was found useful on certain cestodes (Dicranotaenia and Sobolevicanthus). The worms were heavily stained in Ehrlich's hematoxylin, destained in 45% acetic acid, then dehydrated and cleared as in the regular Chubb's method. The results were worms with organs stained varying shades of orange, clearly contrasting with the very light parenchyma. Nematodes were fixed in hot A.F.A. and studied in temporary glycerine-jelly

Table I. Collection dates and localities for lesser scaup and ruddy ducks.

				Apr.	May		June		July		Aug.		Sept.	Oct.	Nov.	Total
				16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-30	1-31	1-15	
Lesser Scaup	Cooking Lake	1964	Adult			11	2	7	3	2	5	3	1	7		41
			Imm.						4	3	2	5	1	1	1	17
		1965	Adult	2		3	5	4	7	4	6	4	3			38
			Imm.							3	3	14	3			23
	Hastings Lake	1964	Adult		1	2	5	5	4	5		2		1	1	26
			Imm.						8	12		1		2	4	27
		1965	Adult				5	5	5	3	3					21
			Imm.							2	2					4
	Iosegun Lake	1965	Adult				4									4
	Misc. Sloughs	64/65	Total		9		2		1				2	1		15
	Total	64/65	Adult													141
	Total	64/65	Imm.													75
Ruddy Ducks	Cooking Lake	1964	Adult			6	4	3	1	7	1	4				26
			Imm.								2	4	5	2		13
		1965	Adult		1	7	5	6	3	3	5	1	2			33
	Hastings Lake	1964	Adult			1	3	3	3							10
			Imm.							6						6
	Misc. Sloughs	64/65	Total			1		3					3	1		8
	Total	64/65	Adult													74
	Total	64/65	Imm.													22

or lactophenol preparations. Acanthocephalans were fixed in A.F.A., then stained with acetic acid-hematoxylin and mounted in balsam.

Initially, ducklings were aged by plumage characteristics (Gollop and Marshall, 1954). However, these categories proved to be too broad. In addition, Schneider (1965) has shown that feather development in young ducks, including lesser scaup, varies with latitude. He also found that rates of increase in weight of birds from Alaska were similar to those at lower latitudes. Thus weight was used as an index of age for this study.

Many of the smaller hymenolepids were often found in very large numbers which tended to make mean values for sampling periods higher than most of the individual readings. Uemura (1964) suggested the use of the median for such data as it does not take into account the actual magnitude of the other values. The median was used throughout this study.

Analysis of the percent occurrence of various food items in the esophagus, proventriculus and ventriculus of the ducks was carried out by the methods of Rogers and Korschgen (1966). No volumetric analysis was made.

Points on graphs of seasonal variation represent two week sampling periods. Small samples taken in the fall for scaup, and spring for ruddies, made it necessary to lump successive two week periods, thus giving values for the entire month.

TAXONOMY

A total of 46 species of helminths, including 13 trematodes, 24 cestodes, 6 nematodes, 2 acanthocephalans, and one leech, were recovered from lesser scaup and ruddy ducks in this study. Taxonomic citations for the helminth species recovered, together with data on their extensity and intensity of infection in adult and immature birds, are presented in Table II.

The taxonomy of some species listed on Table II requires comment:

(1) *Echinoparyphium ?recurvatum* - These specimens resembled three species of *Echinoparyphium* common in ducks (*E. recurvatum*, *E. flexum*, and *E. baculus*). *E. baculus* is a small form described as having no body spines. My specimens had no body spines, probably attributable to poor condition of the worms from frozen birds. Most of the collar spines were also missing on these specimens. In addition, my specimens are three to four times as large as previously described *E. baculus*. According to Najarian, *E. flexum* differs from *E. recurvatum*, in that it has a true seminal receptacle, which is difficult to see. Since no seminal receptacle was observed in my specimens, they have been designated as *E. ?recurvatum*, and a representative sample has been sent to Dr. H. Najarian for positive identification.

(2) *Hymenolepis tuvensis* - Specimens identified as *H. tuvensis* differed in one consistent respect from the original description. In illustrations accompanying the original description, the hooks were shown with a prominent guard. This guard was not as prominent in my material, which agreed with the original description in all other respects.

(3) *Hymenolepis sp.* - One immature hymenolepid was found in

Table II. Summary of helminths recovered from lesser scaup and ruddy ducks.

Helminth Species	Lesser Scaup					Ruddy Ducks				
	Adult (141)		Imm. (75)		Host* Record	Adult (74)		Imm. (22)		Host* Record
	Ext.	Md. Int. Range	Ext.	Md. Int. Range		Ext.	Md. Int. Range	Ext.	Md. Int. Range	
Trematoda										
Orchipedum tracheicola Braun, 1901	2.0	1.0			a			4.0	1.0	a
Renicola sp.	0.7	1.0								
Eucotyle wehri Price, 1930	3.0	1.5 1-51								
Hyptiasmus arcuatus (Brandes, 1892)	11.0	2.0 1-11			a,b	4.0	1.0 1-8			a,b
Typhlocoelum cucumerinum (Rudolphi, 1809)	10.0	1.0 1-12	3.0	9.5 2-17	a,b					
Psilochasmus oxyurus (Creplin, 1825)	0.7	2.0								
Echinoparyphium ?recurvatum (Linstow, 1873)	20.0	4.0 1-750	6.0	9.0 2-20		6.0	2.0 1-48	13.0	9.0 2-91	
Echinostoma revolutum (Froelich, 1802)	0.7	2.0			a	12.0	1.0 1-5	9.0	1.5 1-2	
Notocotylus attenuatus (Rudolphi, 1809)	0.7	1.0				3.0	1.5 1-2	13.0	1.0 1-8	
Apatemon gracilis (Rudolphi, 1819)	45.0	5.0 1-450	10.6	16.5 3-75		54.0	6.0 1-69	36.0	11.5 1-97	a

Table II (cont'd.)

Helminth Species	Lesser Scaup Adult (141) Ext.	Lesser Scaup Adult (141) Md. Int. / Range	Lesser Scaup Imm. (75) Ext.	Lesser Scaup Imm. (75) Md. Int. / Range	Host* Record	Ruddy Ducks Adult (74) Ext.	Ruddy Ducks Adult (74) Md. Int. / Range	Ruddy Ducks Imm. (22) Ext.	Ruddy Ducks Imm. (22) Md. Int. / Range	Host* Record
Cotylurus hebraicus Dubois, 1934	23.0	3.0 / 1-16	6.0	8.0 / 2-75	a	14.0	2.0 / 1-15			a
Dendritobilharzia anatinarum Cheatum, 1941	3.0	1.0			a	1.0	1.0	4.0	1.0	a
Zygocotyle lunata (Diesing, 1836)	6.0	1.0 / 1-3	6.6	1.0 / 1-16						
Cestoda										
Schistocephalus solidus (Müller, 1776)	0.7	2.0			a					
Anomotaenia ciliata Fuhrmann, 1913	3.0	1.0 / 1-5			a,b					
Lateriporus mathevossianae Ryzhikov and Gubanov, 1962	3.0	2.0 / 1-4	1.0	1.0	a,b					
Lateriporus skrjabini Matevosian, 1946	63.0	9.0 / 1-306	69.0	7.0 / 1-1000	a,b	8.0	4.5 / 1-39			a,b
Fimbriaria fasciolaris (Pallas, 1781)	66.0	6.0 / 1-660	46.0	24.0 / 1-364		36.0	3.0 / 1-17	36.0	2.0 / 1-13	a
Gastrotaenia cygni Wolffhügel, 1938	31.0	2.0 / 1-20	1.0	5.0		9.0	1.0 / 1-5	4.0	1.0	
Aploparaksis furcigera (Nitzsch, 1819)						20.0	3.0 / 1-25	18.0	4.0 / 4-54	a

Table II (cont'd.)

	Lesser Scaup					Ruddy Ducks				
	Adult (141)		Imm. (75)		Host* Record	Adult (74)		Imm. (22)		Host* Record
Helminth Species	Ext.	Md.Int. / Range	Ext.	Md.Int. / Range		Ext.	Md.Int. / Range	Ext.	Md.Int. / Range	
Diorchis excentricus Mayhew, 1925						75.0	9.0 / 1-120	50.0	13.0 / 1-200	
Diorchis spinata Mayhew, 1929	6.0	3.0 / 2-31	4.0	1.0 / 1-2	a					
Cloacotaenia megalops (Nitzsch, 1829)	16.0	2.0 / 1-6	5.0	1.5 / 1-16	a	4.0	3.0 / 1-17			a
Dicranotaenia coronula (Dujardin, 1845)	33.0	10.0 / 1-125	9.0	5.0 / 1-10		1.0	2.0			a
Hymenosphenacanthus cyrtoides (Mayhew, 1925)	0.7	68.0	1.0	7.0	a	86.0	96.0 / 2-2700	54.0	67.0 / 1-1800	
Hymenosphenacanthus pittalugai (Lopez-Neyra, 1932)	16.0	28.0 / 1-305	6.0	9.0 / 1-1500	a,b					
Sobolevicanthus octacantha (Krabbe, 1869)			3.0	229.5 / 9-450	a,b					
Sobolevicanthus sp.	9.0	6.0 / 1-35	8.0	4.0 / 1-6						
Hymenolepis abortiva (Linstow, 1904)	3.0	1700.0 / 450-3000	1.0	300.0	a,b					
Hymenolepis arcuata Kowalewski, 1904	5.0	2.0 / 1-23	3.0	1.0						
Hymenolepis compressa (Linton, 1892)			3.0	307.0 / 14-600	a					

Table II (cont'd.)

Helminth Species	Lesser Scaup Adult (141) Ext.	Lesser Scaup Adult (141) Md. Int. / Range	Lesser Scaup Imm. (75) Ext.	Lesser Scaup Imm. (75) Md. Int. / Range	Host* Record	Ruddy Ducks Adult (74) Ext.	Ruddy Ducks Adult (74) Md. Int. / Range	Ruddy Ducks Imm. (22) Ext.	Ruddy Ducks Imm. (22) Md. Int. / Range	Host* Record
Hymenolepis jaegerskioeldi Fuhrmann, 1913	23.0	500.0 1-11000	34.0	191.0 3-8100						
Hymenolepis parvula Kowalewski, 1904	9.0	110.0 1-5400	2.0	34.5 34-35	a,b	..	...			
Hymenolepis spiralibursata Czaplinski, 1956	3.0	100.0 1-300	5.0	22.0 5-100	a,b					
Hymenolepis tuvensis (Spasskaya and Spassky, 1961)	55.0	150.0 1-7000	41.0	270.0 16-8000	a,b					
Hymenolepis sp.						1.0	1.0			
Oligorchis sp.	7.0	1.5 1-5	8.0	1.0 1-4						
Nematoda										
Capillaria anatis (Schrank, 1790)	5.0	2.0 1-30	1.0	1.0		1.0	1.0			
Capillaria contorta (Creplin, 1829)	1.0	1.0				27.0	6.5 1-35	4.0	1.0	
Amidostomum acutum (Lundahl, 1848)	8.0	2.0 1-14								
Epomidiostomum uncinatum (Lundahl, 1848)						48.0	5.0 1-45	40.0	3.0 1-13	

Table II (cont'd.)

	Lesser Scaup					Ruddy Ducks				
	Adult (141)		Imm. (75)		Host* Record	Adult (74)		Imm. (22)		Host* Record
Helminth Species	Ext.	Md.Int. / Range	Ext.	Md.Int. / Range		Ext.	Md.Int. / Range	Ext.	Md.Int. / Range	
Streptocara crassicauda (Creplin, 1829)	13.0	1.0 / 1-14	18.0	3.0 / 1-6		5.0	6.0 / 1-11	4.0	1.0	
Tetrameres spinosa (Maplestone, 1931)	37.0	3.5 / 1-32	21.0	5.5 / 1-24		25.0	3.0 / 1-17			
Acanthocephala										
Polymorphus marilis Van Cleave, 1939	95.0	21.5 / 1-389	60.0	7.0 / 1-156		9.0	1.0 / 1-128	4.0	1.0	a
Corynosoma constrictum Van Cleave, 1918	4.0	6.0 / 4-16				55.0	2.0 / 1-218	50.0	15.0 / 1-41	
Hirudinea										
Theromyzon rude (Baird, 1869)	4.0	1.0 / 1-2	1.3	1.0	a	6.0	2.0 / 2-4	4.0	3.0	a

* a = A new host record.

b = A new North American record.

Ext. = extensity.

Md.Int. = median intensity.

the intestine of a ruddy duck. A few proglottids with testes and ovary were present. The topography of the testes in relation to the ovary resembled that of *Dicranotaenia coronula*, but the strobila was much wider than specimens of *D. coronula* at a similar stage of development. It has been listed as *Hymenolepis sp.* and not *Dicranotaenia sp.* since the diagnostic hooks were not present, and there are other hymenolepids with a similar topography of the genital glands.

(4) *Sobolevicanthus sp.* - These specimens were similar to *Sobolevicanthus gladium* from the greater scaup, *Nyroca* (=*Aythya*) *marila*, as described by Spassky and Bobova (1962). They stated that their specimens were morphologically identical to *Sobolevicanthus dafilae* (Polk, 1942), except for the stylet, which in *S. gladium* has a distinct depression at the tip (Fig. 1). Schiller (1954), however, synonymized *S. dafilae* with *S. stolli* (Brock, 1941), and for the first time described the hooks as 10, 70 μ in length. My specimens are like *S. stolli* in the morphology of the strobila, but have only 8 hooks, 117 μ in length (Fig. 3). They are also similar to the strobilae of *S. gladium* except for the distal end of the stylet. In my specimens (Fig. 2), it is smooth, curved slightly to the posterior at the tip and has no depression at the distal end. No hooks have been described for *S. gladium*.

(5) *Oligorchis sp.* - Mature specimens of an apparently new species of the genus *Oligorchis* were collected from an adult scaup taken at Iosegun Lake. A small proportion of the scaup from Cooking and Hastings Lakes harbored immature specimens of this worm.

My specimens have 6-8 testes, and thus differ from most other *Oligorchis*, which have four testes. They also differ from *Oligorchis paucitesticulatus* (Fuhrmann, 1913), which has 7-11 testes, in the structure of the hooks (Fig. 4) and the size of the cirrus sac

(390 μ in my specimens; 68μ in O. paucitesticulatus as described by Fuhrmann, and 115-140 μ in the same species as described by Deblock and Rosé, 1946).

This species will be described elsewhere.

Figure 1 Sobolevicanthus gladium - male terminal genitalia (after Spassky and Bobova, 1962).

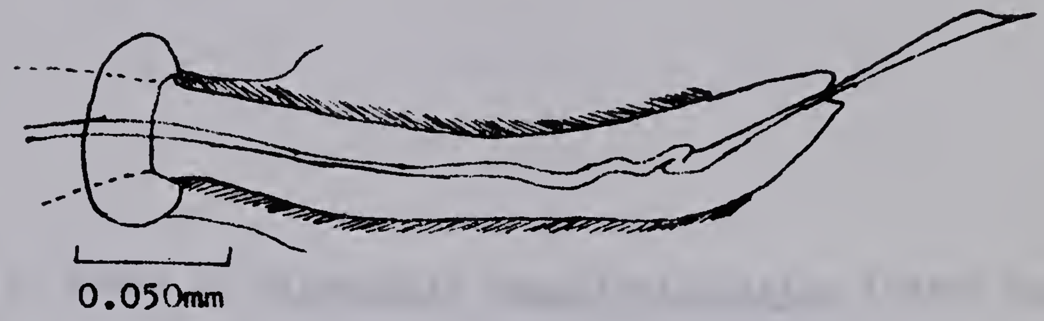


Figure 2 Sobolevicanthus sp. - male terminal genitalia.

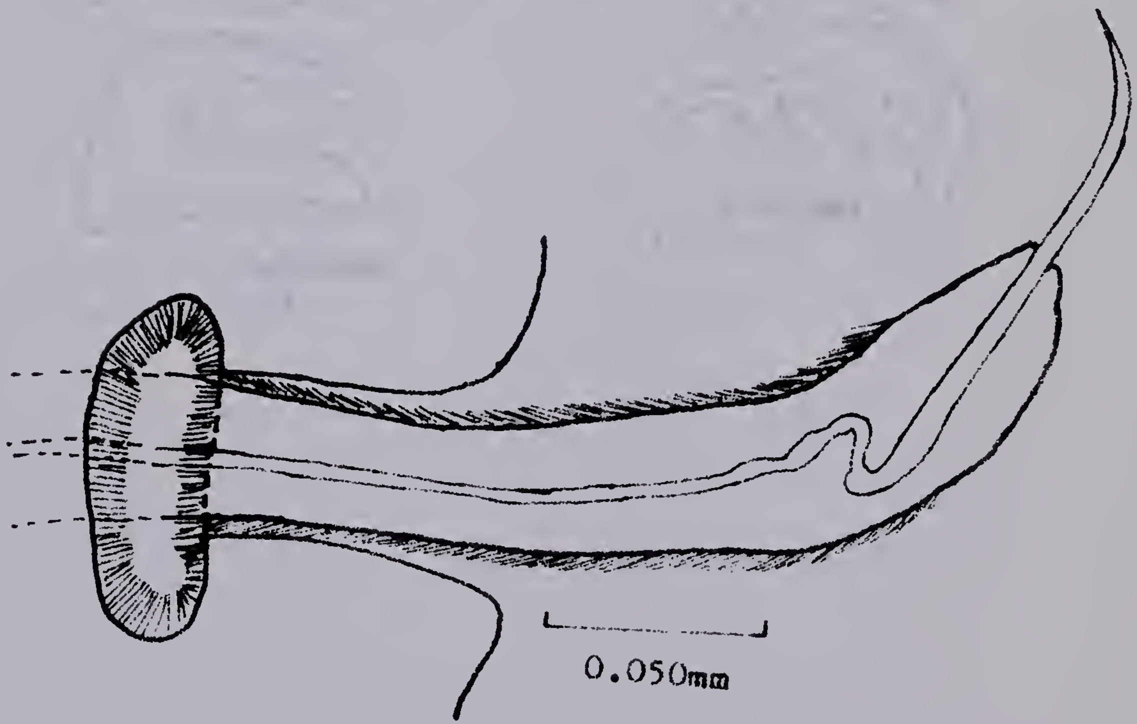


Figure 3 Sobolevicanthus sp. - rostellar hooks.

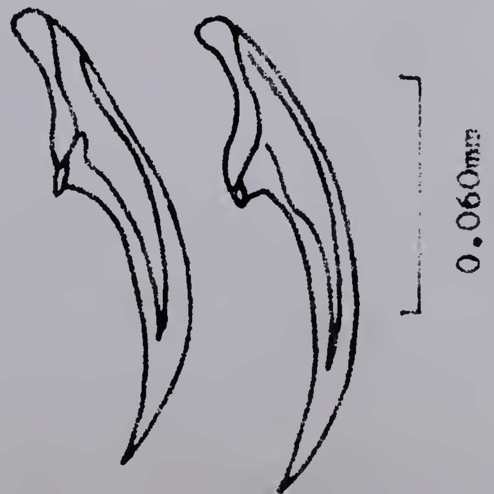
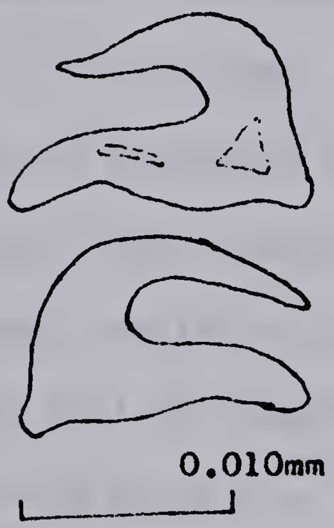
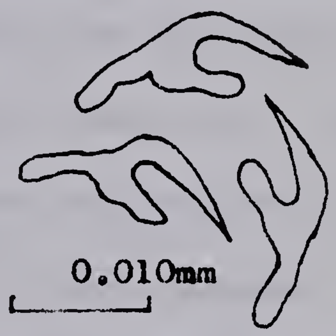


Figure 4 A. Hooks of <u>Oligorchis paucitesticulatus</u> (after Deblock and Rosé, 1964).

B. Hooks of <u>Oligorchis sp</u>.



A.



B.

SPECIFICITY

The helminth species found in this study have been placed in the categories proposed by Gallimore (1964) (Table III). Lesser scaup were main hosts of 13 species, auxiliary hosts of 17 species, accidental hosts of 9 species, and inhibitory hosts of 3 of the 42 species found in these birds. Ruddies were main hosts of 6 species, auxiliary hosts of 11 species, accidental hosts of 4 species, and inhibitory hosts of 3 of their 24 species of helminths.

The lesser scaup, being the most common anatid on the lakes and one of the most common birds, could be expected to play an important role in the characterization of the helminth fauna of other birds ecologically associated with it. Few of these other birds have been investigated thoroughly, but 21 of the 30 helminths for which scaup are the main or auxiliary hosts have already been recorded from these other birds. Since scaup are the most abundant anatids on the lakes, they are responsible for a large proportion of the pool of infective stages in invertebrates.

The important role scaup play in the maintenance of helminth life cycles can best be examined by analyzing the accidental and inhibitory categories for ruddies, coots (data from Colbo, 1965), and grebes (data from Gallimore, 1964). Five helminths for which the scaup is the host are accidental or inhibited in ruddies. The scaup is also a main or auxiliary host for seven helminths found in coots. Grebes appear to have a distinctive helminth fauna of their own; however, scaup still contribute some forms to the helminth community in grebes. Scaup are main or auxiliary hosts for two of the five grebe helminths which could be traced to other water birds in the area.

An excellent example of the central role of scaup in the

Table III. Host categories, based on specificity, for the helminths recovered from lesser scaup, ruddy ducks and American coots.

Helminth	Lesser Scaup	Ruddy Ducks	American Coots (Colbo, 1965)
Trematoda			
Orchipedum tracheicola	Inhib.	Inhib.	Inhib.-Aux.
Renicola sp.	Acc.		
Eucotyle wehri	Acc.		
Hyptiasmus arcuatus	Main	Acc.	
Typhlocoelum cucumerinum	Main		
Psilochasmus oxyurus	Acc.		
Echinoparyphium ?recurvatum	Aux.	Aux.	
Echinostoma revolutum	Acc.	Aux.	Acc.
Notocotylus attenuatus	Acc.	Aux.	
Apatemon gracilis	Aux.	Aux.	
Cotylurus hebraicus	Main	Aux.	Aux.*
Dendritobilharzia anatinarum	Aux.	Acc.	
Zygocotyle lunata	Aux.		
Cestoda			
Schistocephalus solidus	Acc.		Aux.
Anomotaenia ciliata	Aux.		
Lateriporus mathevossianae	Inhib.		Inhib.
Lateriporus skrjabini	Main	Inhib.	Inhib.
Fimbriaria fasciolaris	Main	Aux.	
Gastrotaenia cygni	Main	Aux.	
Aploparaksis furcigera		Main	Acc.
Diorchis excentricus		Main	
Diorchis spinata	Aux.		
Cloacotaenia megalops	Aux.	Aux.	Inhib.
Dicranotaenia coronula	Main		
Hymenosphenacanthus cyrtoides	Inhib.	Main	
Hymenosphenacanthus pittalugai	Main		
Sobolevicanthus octacantha	Acc.		
Sobolevicanthus sp.	Aux.		
Hymenolepis abortiva	Aux.		
Hymenolepis arcuata	Aux.		
Hymenolepis compressa	Acc.		
Hymenolepis jaegerskioeldi	Main		
Hymenolepis parvula	Aux.		
Hymenolepis spiralibursata	Aux.		
Hymenolepis tuvensis	Main		
Hymenolepis sp.		Inhib.	
Oligorchis sp.	Main		

Table III. (cont'd.)

Helminth	Lesser Scaup	Ruddy Ducks	American Coots (Colbo, 1965)
Nematoda			
Capillaria anatis	Aux.	Acc.	
Capillaria contorta	Acc.	Main	
Amidostomum acutum	Aux.		
Epomidiostomum uncinatum		Main	
Streptocara crassicauda	Aux.	Aux.	Inhib.
Tetrameres spinosa	Main	Aux.	
Acanthocephala			
Polymorphus marilis	Main	Acc.	Inhib.
Corynosoma constrictum	Aux.	Main	Inhib.
Hirudinea			
Theromyzon rude	Aux.	Aux.	Aux.

Main - Main host

Aux. - Auxiliary

Acc. - Accidental host

Inhib. - Inhibitory host

* Colbo (1965) placed *Cotylurus hebraicus* in the main host category; because of data presented in this study it has been placed in the auxiliary category.

circulation of a helminth, found in various water birds, is the circulation of the cestode Lateriporus skrjabini. In studies done in cooperation with Mr. M. Denny, cysticercoids of L. skrjabini from Gammarus lacustris were fed to a variety of laboratory-reared ducklings. In addition, a variety of water birds from Cooking Lake was examined for L. skrjabini. The resulting data on host specificity from both laboratory and field studies are summarized in Table IV.

Only the three species of the genus Aythya were found to harbor mature worms, even though many other water birds were exposed to natural or experimental infections. Scaup are by far the most common of the three species of Aythya on Cooking and Hastings Lakes, feed more frequently on animal material than the others, and are undoubtedly responsible for seeding the vast majority of the gammarids. Only a few canvasbacks and redheads were examined, but the low extensity and intensity of infection with L. skrjabini suggest that these ducks may not be capable of maintaining the tapeworm at existing population levels. The other hosts in Table IV harbored only immature tapeworms, although the extensity and intensity of these immature worms was high in coots (Colbo, 1965) and the few white-winged scoters examined. Apparently scaup act as an effective reservoir for the transmission of L. skrjabini to other water birds.

Besides contributing helminths to other birds, the scaup also receive some forms; scaup are accidental or inhibitory hosts for 12 species of helminths. Three trematodes (Renicola sp., Psilochasmus oxyurus, and Eucotyle wehri) were found almost entirely in the spring, and may be more common on the wintering grounds. The Renicola life cycles studied to date involve marine gastropods (Stunkard, 1964). Sobolevicanthus octacantha and Hymenolepis compressa were found only in birds taken from a small slough which had a large number of dabbling ducks, the usual hosts

Table IV. Host specificity of *Lateroporus skrjabini*.

	Laboratory Infections*	Field Observations			Host Category
		Ext.	Intensity Md. (Range)	Development	
Order Anseriformes					
Anas platyrhynchos domesticus (Domestic Mallard) Rouin and Pekin Strains	Imm.				Inhib.
Anas platyrhynchos platyrhynchos (Wild Mallard)	Negative	2/5	60(33-87)	Imm.	Inhib.
Anas acuta (Pintail)	Negative				Inhib.
Anas discors (Blue-winged Teal)	Negative				Inhib.
Anas strepera (Gadwall)		1/2	5		Inhib.
Mareca americana (Baldpate)		1/3	2		Inhib.
Aythya affinis (Lesser Scaup)	Mature	63%	9(1-306)	Mature	Main
Aythya americana (Redhead)	Mature	1/5	6	Mature	Aux.
Aythya valisineria (Canvasback)	Mature	1/2	7	Mature	Aux.
Melanitta deglandi (White-winged Scoter)		3/5	200(56-250)	Imm.	Inhib.
Bucephala albeola (Bufflehead)		3/8	5(1-21)	Imm.	Inhib.
Oxyura jamaicensis (Ruddy)		8%	5(1-39)	Imm.	Inhib.

Table IV (cont'd.)

	Laboratory Infections*	Field Observations			Host Category
		Ext.	Intensity Md. (Range)	Development	
Order Podicipediformes (data from Gallimore, 1964)					
Podiceps grisegena (Red-necked Grebe)		2/77	3(1-4)	Imm.	Inhib.
Podiceps caspicus (Eared Grebe)		2/166	1	Imm.	Inhib.
Order Gruiformes (data from Colbo, 1965)					
Fulica americana (Coot)		30/230	10**(1-64)	Imm.	Inhib.

* Imm. Only immature worms recovered on feeding cysticeroids to laboratory reared ducklings.

Mature Mature worms recovered.

Negative No worms recovered.

** A mean value.

of these species, and were probably obtained from the other ducks as a result of the restricted habitat. Lateriporus mathevossianae was a characteristic parasite of white-winged scoters. The ruddy is the main host for Hymenosphenacanthus cyrtoides and Capillaria contorta. Schistocephalus solidus, Echinostoma revolutum and Notocotylus attenuatus are helminths of wide specificity, found in a wide variety of birds. Orchipedum tracheicola has been reported from various Anseriformes and Charadriiformes, but in this area fully mature specimens have been recovered only from the Bonaparte's gull.

Ruddy ducks, the second most abundant species of duck on the study area, and the main or auxiliary hosts for 17 species of helminths, are also important in the circulation of helminths in Cooking and Hastings Lakes.

Ruddies overlap with scaup in the maintenance of the infective pool for ten helminths for which both ducks are main or auxiliary hosts (Table III). Ruddies are the major contributors to the infective pool for three of these helminths (Apatemon gracilis, Corynosoma constrictum and Theromyzon rude); scaup are more important for the other seven (see also Table II).

Ruddies overlap with other birds in the maintenance of five additional helminth species (Echinostoma revolutum, Notocotylus attenuatus, Aploparaksis furcigera, Capillaria contorta and Epomidiostomum uncinatum). Since ruddies are more abundant than other ducks, they are responsible for a major part of the infective pool for these five helminths.

The ruddy duck is the main host for the two remaining forms (Diorchis excentricus and Hymenosphenacanthus cyrtoides) which were found only rarely in other water birds. Circulation of these forms appears to be one-way, with ruddies maintaining the infective pool for a slight "spill-

over" to other water birds.

From the above discussion it is apparent that one of the main patterns of helminth circulation is from lesser scaup to other water birds. Scaup in return receive relatively few helminths from these birds. Ruddies are also important for the maintenance of the infective pool of a number of helminths.

FACTORS HAVING LITTLE INFLUENCE ON HELMINTH POPULATIONS

The mean and median helminth burdens of male and female adult scaup and ruddies, as well as of immature scaup (over 200 gm.) are summarized in Table V. The sample of immature ruddies was too small to be included here.

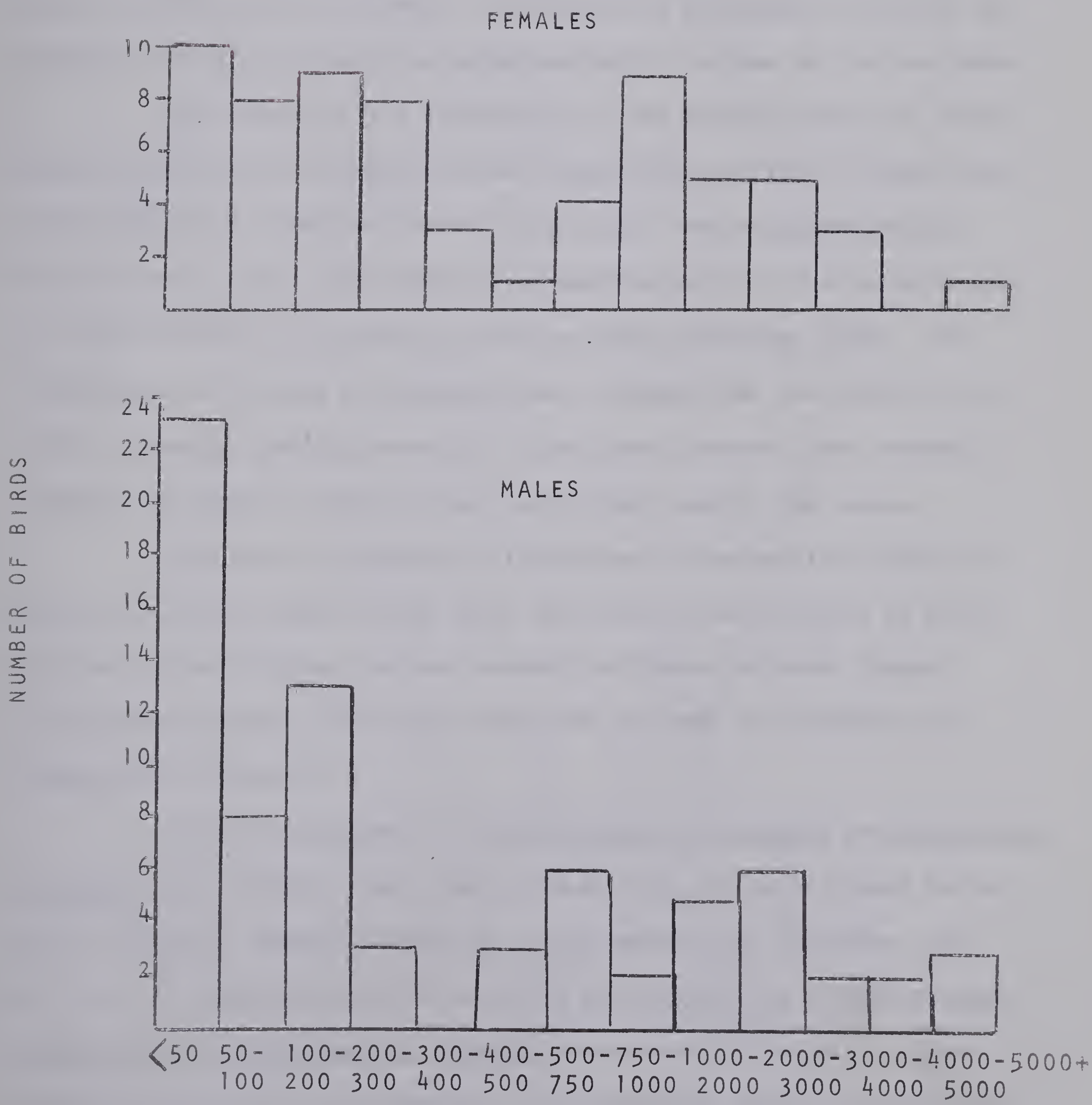
Table V. Comparative helminth burdens of male and female lesser scaup and ruddy ducks.

	Males		Females	
	$\bar{X}$	Md.	$\bar{X}$	Md.
Lesser Scaup				
adults	892	144	922	242
immatures	1859	1478	1560	1109
Ruddy Ducks (adults)	260	124	279	121

Although a variety of statistical analyses applied to the data showed no significant differences between males and females, adult male scaup appeared to have fewer helminths than adult females. Figure 5 shows that a larger number of males have a total helminth burden of less than 50 worms. This difference was statistically significant, (X^2 = 12.6 with one degree of freedom), but could not be correlated with behavioral or seasonal differences.

The basic weather patterns in the two years of this study were quite different: 1964 was dry, with very low water levels, and 1965 moist with much higher water levels. These conditions were similar to those encountered by Colbo (1965), so that differences in the helminths of the scaup and ruddies in the two years, along the lines of the differences

Figure 5. Comparative distribution of total helminth burdens in male and female adult scaup.



Colbo found in the helminths of coots, were expected. However, the major helminths of both species of ducks were present, in essentially the same numbers, in the two years and the seasonal fluctuations of these major species showed the same patterns in both years.

Even though Kerekes (1965) found limnological differences between Cooking and Hastings Lakes, the helminth faunas of scaup and ruddies from the two lakes showed no major differences. All the major species were found in birds from both lakes. The numbers of helminths as well as the seasonal distribution patterns were essentially the same in the two lakes.

The absence of any differences in the helminth fauna of these ducks between years or between lakes suggests that neither of these variables affected the habitats selected by them. Both scaup and ruddies tend to feed in open water, over submerged vegetation. The invertebrates in such situations are similar in the two lakes (Kerekes, 1965). The differences in Cooking and Hastings Lakes between 1964 and 1965 did not affect the major feeding areas for diving ducks, whereas they markedly affected the shallow reed beds and shore areas used by the coots.

Although no significant differences in the helminth faunas of birds from the two major study areas were found, small samples of scaup from two other habitats did show markedly different helminth faunas. Data on the helminths from birds collected in these two habitats are summarized in Table VI.

The only infections of Sobolevicanthus octacantha and Hymenolepis compressa found in this study were in ducks from the small slough habitat. There was also a notable absence of the gammarid-borne parasites, (see p. 43). In addition, they harbored the only infections of Typhlocoelum cucumerinum and Dicranotaenia coronula encountered in the fall. These differences can all be attributed to the restricted nature of the habitat.

Table VI. The helminths of lesser scaup from Iosegun Lake and slough habitats.

Helminths	Iosegun Lake (4 adults) No. Inf.	Iosegun Lake (4 adults) Intensity Md. (Range)	Slough (2 ducklings) No. Inf.	Slough (2 ducklings) Intensity Md. (Range)
Trematoda				
Typhlocoelum cucumerinum			2	10(2-17)
Echinoparyphium ?recurvatum	4	9(1-20)	1	20
Apatemon gracilis	4	3(1-63)	1	75
Cotylurus hebraicus	2	4(3-4)	1	8
Zygocotyle lunata			2	10(4-16)
Cestoda				
Fimbriaria fasciolaris	4	19(1-23)	1	1
Gastrotaenia cygni	1	3		
Diorchis spinata			1	1
Cloacotaenia megalops			2	2(1-2)
Dicranotaenia coronula	2	7(3-10)	1	5
Hymenosphenacanthus pittalugai			1	95
Sobolevicanthus octacantha			2	230(9-450)
Hymenolepis arcuata	1	23	2	1
H. compressa			2	307(14-600)
H. jaegerskioeldi	4	80(32-500)		
H. spiralibursata	1	16		
H. tuvensis	4	68(24-222)		
Oligorchis sp.	3	16(7-12)		

Table VI (cont'd.)

Helminths	Iosegun Lake (4 adults) No. Inf.	Iosegun Lake (4 adults) Intensity Md. (Range)	Slough (2 ducklings) No. Inf.	Slough (2 ducklings) Intensity Md. (Range)
Nematoda				
Capillaria contorta			50	1
Tetrameres spinosa	1	1		
Amidostomum acutum	2	1		
Acanthocephala				
Polymorphus marilis	4	5(4-5)		

No. Inf. = number infected.

Md. = median.

The four scaup from Iosegun Lake, 50 miles northwest of Whitecourt, Alberta, were collected from a shallow bay. Iosegun Lake is generally deeper than Cooking or Hastings Lakes and supports large populations of whitefish, tulibee, walleye, and northern pike. The gammarid-borne parasites were less abundant and restricted to relatively small numbers of _Hymenolepis tuvensis_, _Hymenolepis jaegerskioeldi_, and _Polymorphus marilis_. Helminths involving ostracods, copepods, and molluscs were much more abundant than in birds collected from the main study area at the same time of year.

Although the samples of birds from these two habitats were small, the marked differences in their helminth faunas from those of birds taken in the main study areas suggest that more significant limnological differences than exist between the main study areas may result in pronounced differences in helminth populations.

THE INFLUENCE OF AGE ON HELMINTH POPULATIONS

Scaup began to acquire helminths early (one of seven individuals of the youngest age class, those less than 30 gm , or approximately three days of age or less, was infected) and were 100 percent infected (the adult situation) by the 100-200 gm class or roughly three weeks of age (Fig. 6). The mean number of helminth species increased less rapidly, but reached a level near 6 (mean number of species in adults 6.49) in the 200 to 300 gm class or roughly four to five weeks of age.

The cumulative acquisition of helminth species by immature scaup is shown in Fig. 7. There was a steady acquisition of new species through the 500-600 gm class (roughly seven weeks of age).

The median number of helminths for each weight class shows a slow initial rise followed by a large increase starting at the 200-300 gm class (Fig. 7). By the time young birds reach 400 gm or more they are more heavily infected than adult birds taken at the same time (after the middle of July). The general trend for the intensity of infection to be much higher in immature birds may be due to a lowered resistance as suggested by Colbo (1965).

The order of acquisition of representatives of the major groups of helminths was acanthocephalans, then cestodes, trematodes and, finally, nematodes (Table VII). Although this order was not the same as that found by Bychovskaya-Pavlovskaya (1962)(cestodes, acanthocephalans, nematodes and lastly trematodes), or that of Cornwell and Cowan (1963)(trematodes and cestodes first), it does closely approximate the order of abundance of these groups in adult birds (Fig. 8). Cestodes were slightly more common than acanthocephalans, but both were found in more than 95 percent of the birds.

Figure 6. Rate of acquisition of helminths in immature lesser scaup

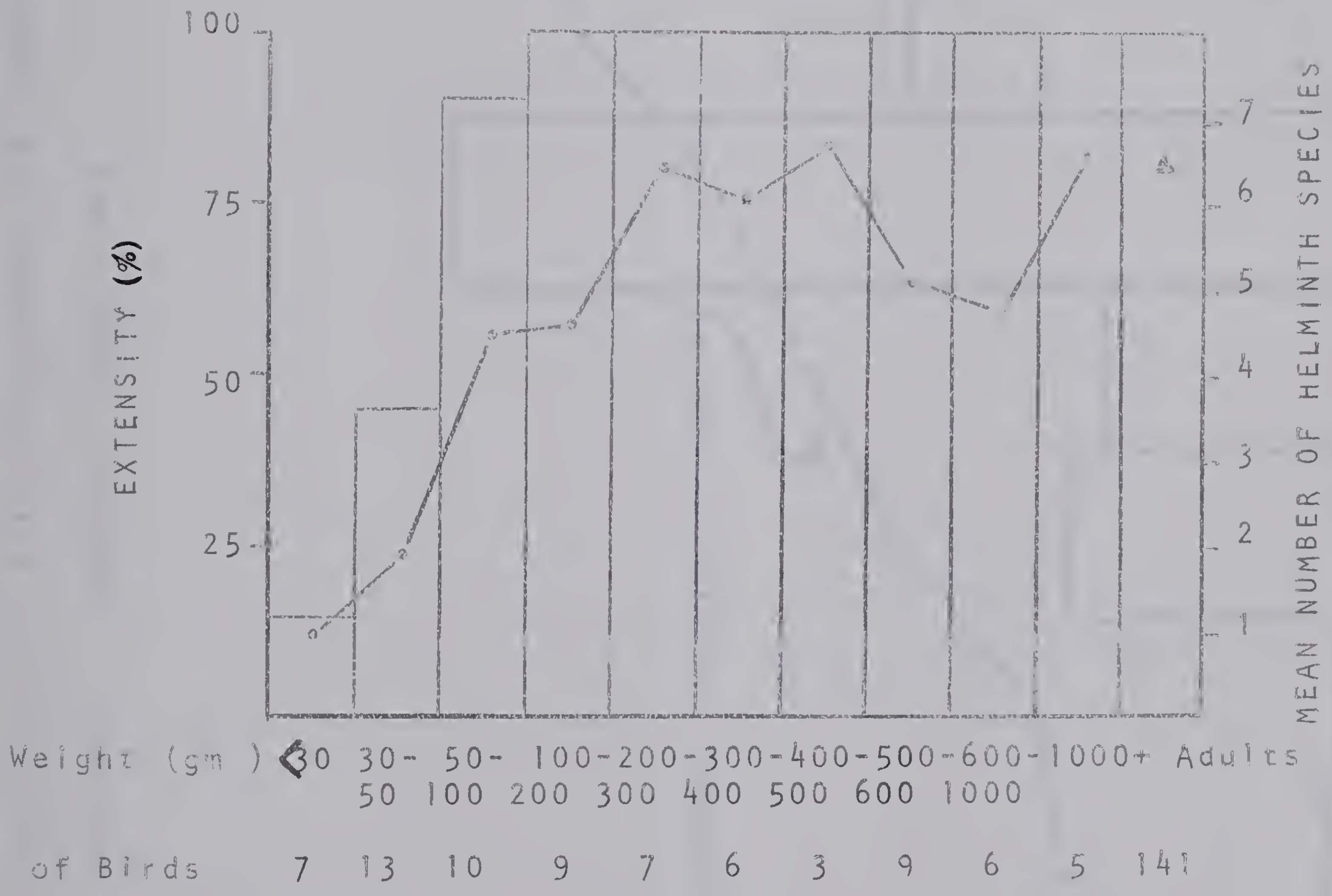


Figure 7. Acquisition of helminth species and numbers of helminths in immature lesser scaup.

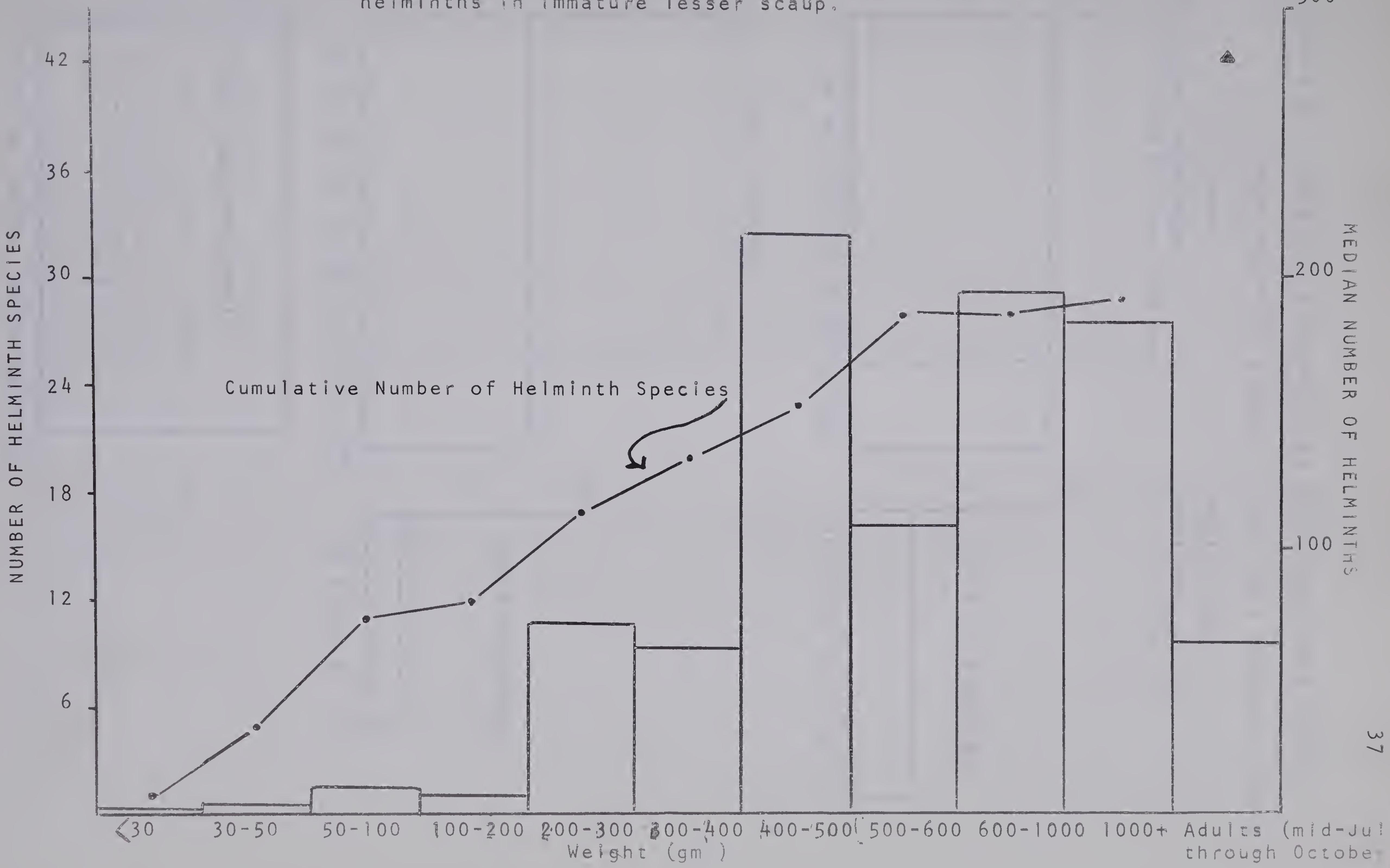


Figure 8. Comparative extensities and intensities of the major helminth groups in adult and immature lesser scaup.

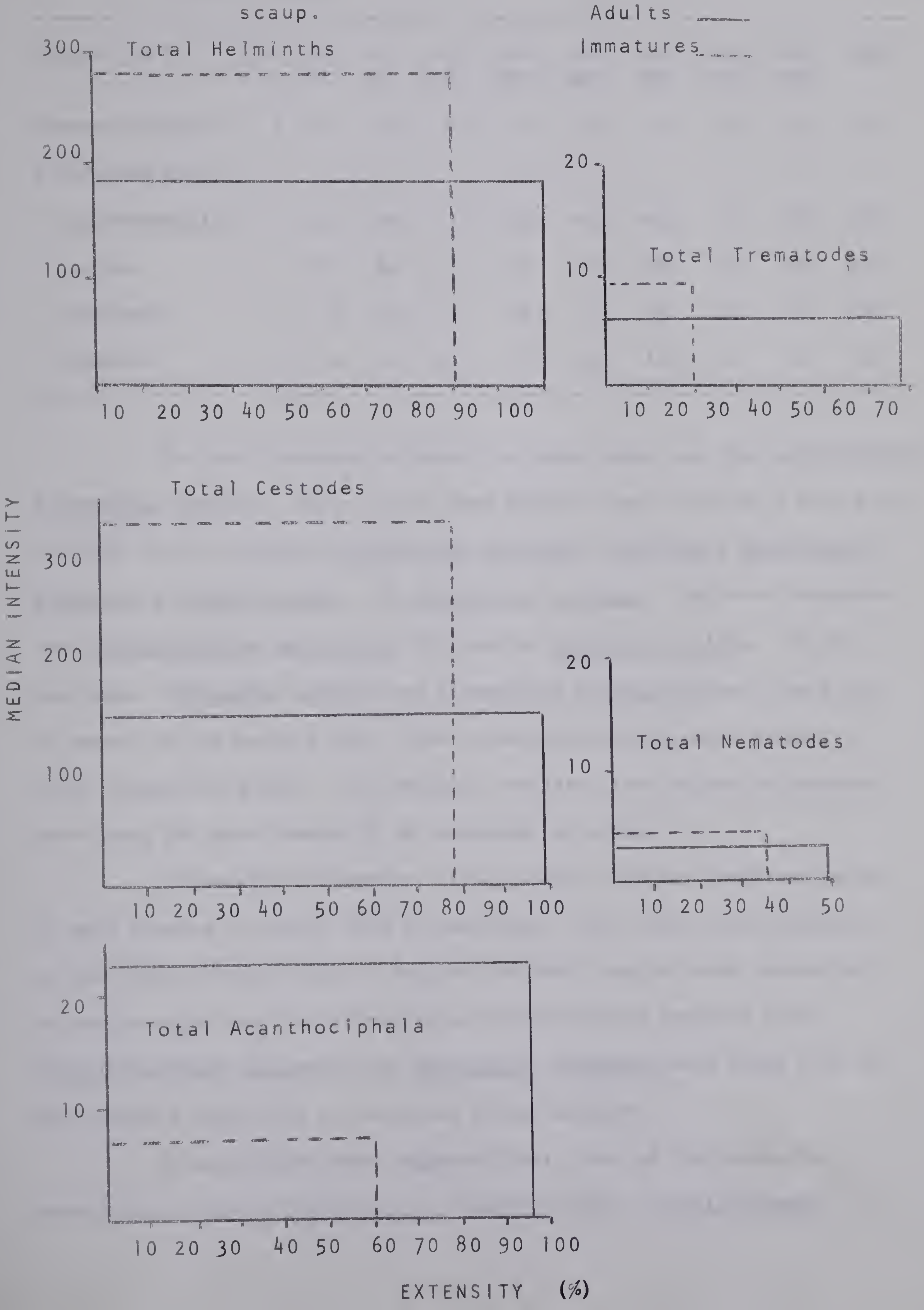


Table VII. Order of acquisition of major helminth groups in immature lesser scaup.

Weight (gm)	<30	30-50	50-100	100-200	200-300	300-400	400-500	500-600	600-1000	1000+
Number of birds	7	13	10	9	7	6	3	9	6	5
% infected with:										
Acanthocephala	14	15	60	33	100	66	100	78	100	100
Cestoda	0	46	80	100	100	100	100	100	100	100
Trematoda	0	0	20	11	28	17	33	33	0	100
Nematoda	0	0	0	55	57	83	66	55	66	40

The first helminth to appear in young scaup was the acanthocephalan, Polymorphus marilis. Scaup in the next weight class (30-50 gm) were also infected by the cestodes, Lateriporus skrjabini, Fimbriaria fasciolaris, Hymenolepis jaegerskioeldi, and Hymenolepis tuvensis. The first trematode was Echinoparyphium recurvatum, followed by Apatemon gracilis. Of the nematodes, Tetrameres spinosa and Streptocara crassicauda were the first to appear in the young scaup. These helminths were the most common in their respective groups. In addition, the first five helminths acquired were among the most common of the helminths of scaup.

Bychovskaya-Pavlovskaya (1962) stated that the trematode fauna is more diverse in adults than in immatures. This idea can be extended to the total helminth fauna. Thirteen helminth species were restricted to adults while only two helminths occurred solely in immature birds. (Sobolevicanthus octacantha and Hymenolepis compressa were found only in two immature birds from a restricted slough habitat.)

It has already been suggested that three of the helminths restricted to adults (Renicola sp., Eucotyle wehri and Psilochasmus

oxyurus)may be forms transmitted on the winter ground. The absence of the cyclocoelid, *Hyptiasmus arcuatus*, from immature birds could be due to a long developmental period within the host, similar to that Ginetsinskaya and Saakova (1952) found for *Cyclocoelum mutabile*. *Amidostomum acutum* was not found in adults after mid-July. It appears to be a spring and early summer helminth, and thus may not be available to young scaup. The other species restricted to the adults were found at low extensities.

THE INFLUENCE OF CONDITION OF THE HOST ON HELMINTH POPULATIONS

Although there was no general correlation between the emaciation index (E.I.) and helminth burdens, two birds in poor condition are of interest. Data on these two birds, one with a missing leg, the other having tuberculosis and an abdominal fibrosis are summarized in Table VIII. It is readily apparent that these birds had a greater number and diversity of helminths than normal. In addition, A-85-65 had the largest infections of the gammarid-borne parasites, *Lateriporus skrjabini*, *Polymorphus marilis* and *Streptocara crassicauda*, that were recorded from adult scaup. *S. crassicauda* were found in the esophagus of this bird rather than in their normal habitat under the gizzard lining. This bird could not dive and was therefore unable to feed normally. From the helminths recovered, it is apparent that this bird relied heavily on gammarids, which were common in the surface waters.

The presence of *Hymenosphenacanthus cyrtoides* (a characteristic parasite of ruddy ducks which was not found in any other adult scaup) in the bird with tuberculosis, suggests that the resistance to infection is lowered in birds in poor condition.

Bezubik (1956) suggested that large numbers of helminths can cause poor condition. Another suggestion, that poor condition may alter food habits and/or lower resistance so that an abnormally large number and variety of helminths can infect the bird, warrants consideration.

Table VIII. Helminths of two lesser scaup in poor condition compared with those considered as normal.

Autopsy Number	E.I.	Condition	Autopsy	Cestodes		Trematodes		Nematodes		Acanthocephala		Total Helminths	
				No. Species	No.	No. Species	No.	No. Species	No.	No. Species	No.	No. Species	No.
A-85-65	0.29	One leg missing	Complete	5	334	5	31	3	70	1	389	14	824
A-124-65	0.50	Tuberculosis and cancer	Trachea, lungs*, liver, kidneys, esophagus and proventriculus not examined.	7	460	2	76	1	5	1	96	11	637
Total Adult Sample (141)**	0.94	Normal	Complete	3.6	152	1.2	6	0.65	3	0.94	23	6.49	186

* These organs were required by the Veterinary Laboratory, Alberta Department of Agriculture for diagnosis of the condition, and could have harbored additional species of helminths. The trachea of other birds often harbored the trematode Typhlocoelum cucumerinum, while the esophagus and proventriculus often harbored the nematodes Capillaria contorta and Tetrameres spinosa.

** Mean values are given for the number of species; median values for number of individual helminths in the total adult sample.

THE INFLUENCE OF FOOD HABITS ON HELMINTH POPULATIONS

Table IX shows the percent occurrence of food items in adult and immature scaup and ruddies. Vegetable matter was found in a high proportion of both species but appeared to make up less than 25 percent of the total material present in scaup, and closer to 50 percent of the total material in ruddies. Although various animal foods were available, scaup fed extensively on gammarids while ruddies fed extensively on chironomids. Chironomids were also present in a fair proportion of the scaup, but were usually found in low numbers. These data agree with the published results of Rogers and Korschgen (1966) for scaup and Cottam (1939) for ruddies.

Since both ducks showed restricted and different food habits, marked differences in the helminth fauna of the two were expected, especially since the vast majority of helminths recovered were biohelminths. Table X shows the percentage of each species of duck infected with helminths having different types of life cycles. The scaup's heavy use of gammarids is reflected by their helminth fauna. A minimum of 9 species (21 percent) of the 42 helminths recovered from scaup use gammarids as an intermediate host.

These gammarid-borne helminths are Orchipedum tracheicola, Lateriporus mathevossianae, Lateriporus skrjabini, Fimbriaria fasciolaris (which also has ostracods and copepod intermediate hosts), Hymenolepis abortive, Hymenolepis jaegerskioeldi, Hymenolepis tuvensis, Streptocara crassicauda and Polymorphus marilis. Tetrameres spinosa, in view of the life cycles of other tetramerids, could probably be added to this group. These forms include 6 of the 11 most common helminths found in scaup (Table II) and are to a large extent responsible for shaping the characteristic helminth fauna of scaup.

Table IX. Percent occurrence of food items eaten by adult and immature lesser scaup and ruddy ducks.

	Lesser Scaup			Ruddy Ducks	
	Total Sample				
	Adults	Imm.	Iosegun Lake	Adults	Imm.
No. Examined	141	75	4	74	22
Plant	100	89	100	100	100
seeds	100	86	100	98	100
Potamogeton sp.	2	1	0	4	0
unidentified plant	60	53	50	65	90
Animal					
Hirudinea	11	1	0	4	0
Crustacea					
Amphipods	29	54	0	4	9
Acanthocephalan cysts	44	44	0	0	0
Cladocerans	1	0	0	0	0
Insecta:					
Chironomids					
larvae	26	13	50	60	18
pupae	12	5	0	20	4

Table IX (cont'd.)

	Lesser Scaup			Ruddy Ducks	
	Total Sample				
	Adults	Imm.	Iosegun Lake	Adults	Imm.
Coleoptera					
Dytiscidae (larvae)	2	0	0	0	0
Gyrinidae (adult)	0	4	0	0	0
Odonata (larvae)	2	0	0	0	0
Trichoptera (larvae	2	1	0	0	4
Hemiptera (adult corixids)	2	4	0	1	13
Hymenoptera (adult)	1	4	0	0	0
Diptera (adult)	1	0	0	0	0
Mollusca					
Unidentified parts	2	1	100	0	0
Pelecypoda					
<u>Pisidium</u> <u>sp</u>.	5	1	100	0	0
Unidentified Sphaeriid	1	0	75	0	0

Table IX (cont'd.)

	Lesser Scaup			Ruddy Ducks	
	Total Sample				
	Adult	Imm.	Iosegun Lake	Adult	Imm.
Gastropoda					
Valvata sp.	1	0	100	0	0
Physidae	1	0	0	0	0
Lymnaeidae	1	0	0	0	0

Table X. Percent of lesser scaup and ruddy ducks infected with helminths with various life cycles.

	No. of Species of Helminths	Lesser Scaup			Ruddy Ducks	
		Adults (141)	Imm. (75)	Iosegun (4)	Adults (74)	Imm. (22)
Cysts in intermediate hosts						
Gastropods	5	36	8	100	21	22
Oligochaetes	1	0	0	0	20	13
Leeches	2	46	13	100	54	36
Cladocerans	1	3	0	0	0	0
Ostracods and copepods*	6	87	50	100	39	40
Ostracods and copepods minus *Fimbriaria**	5	47	17	75	1	0
Gammarids*	9	100	78	100	45	40
Gammarids minus *Fimbriaria**	8	99	77	100	15	9
Cysts on vegetation	2	7	6	0	2	13
Direct life cycle	4	14	1	50	63	40

* *Fimbriaria fasciolaris* uses ostracods and copepods, as well as amphipods, as imtermediate hosts.

The ruddies' heavy use of chironomids is not shown by their helminths. Unfortunately, the life cycles for the three most common helminths of ruddy ducks are unknown, and consequently they could not be included in Table X. One of these, Diorchis excentricus, probably uses ostracods as intermediate hosts, as do other recorded diorchids (Jarecka, 1961).

A comparison of Tables IX and X shows that many helminths were recovered which have intermediate hosts rarely or never encountered in the food analysis. Colbo (1965) and others have indicated that conventional food analyses do not give accurate pictures of food habits since resistant items are retained in the ventriculus while softer items pass through quickly. The occurrence of cysts from gammarids in a higher proportion of adult scaup than the gammarids themselves illustrates this point.

The difference in helminth faunas of the four scaup from Iosegun Lake (p. 34) is apparently due to differences in the food eaten. The relative absence of gammarid-borne parasites (Table VI) reflects the comparative absence of these amphipods in Iosegun Lake and from the diet of scaup collected there. However, these birds fed heavily on molluscs, reflected by the much higher occurrence of trematodes. Those helminths involving ostracods and copepods were also more abundant in the Iosegun Lake birds. It is likely that these small forms are picked up accidentally, and that birds feeding on molluscs, especially the benthic forms, are more likely to pick up these crustaceans than birds feeding on gammarids.

Seasonal changes in food habits are shown in Figs. 9 and 10. Both adult and immature scaup feed extensively on gammarids in mid-summer when these are abundant. There is a decrease in the use of chironomids and leeches as a food source during this same period. Chironomids make up the bulk of the animal food taken by ruddies during all periods

examined, and show a peak use during late July and August.

These seasonal changes in food habits would be expected to influence helminth populations, and will be discussed further in the next section.

Figure 9. Seasonal variation in major food items in adult and immature lesser scaup (data for 1964 and 1965 pooled).

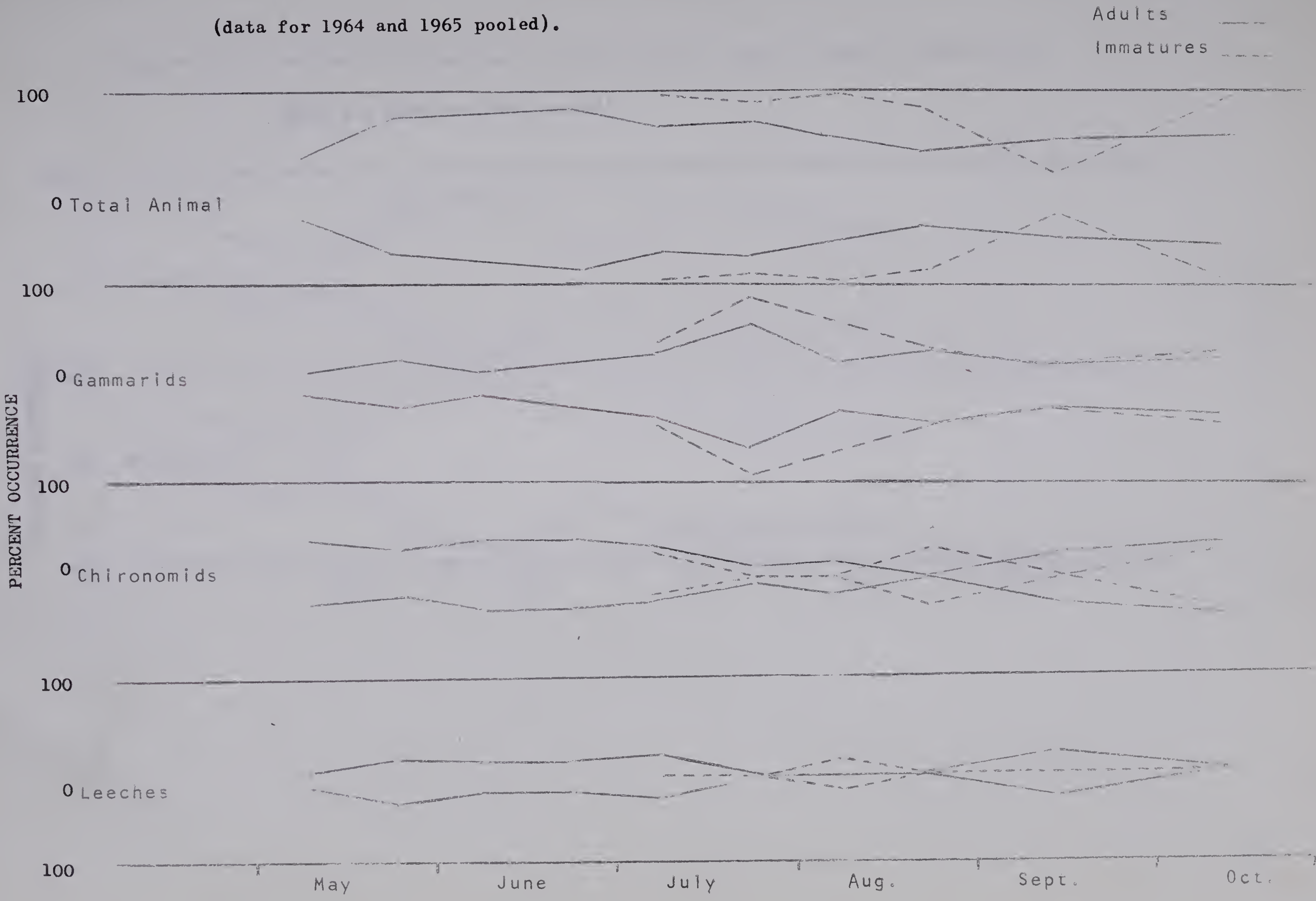
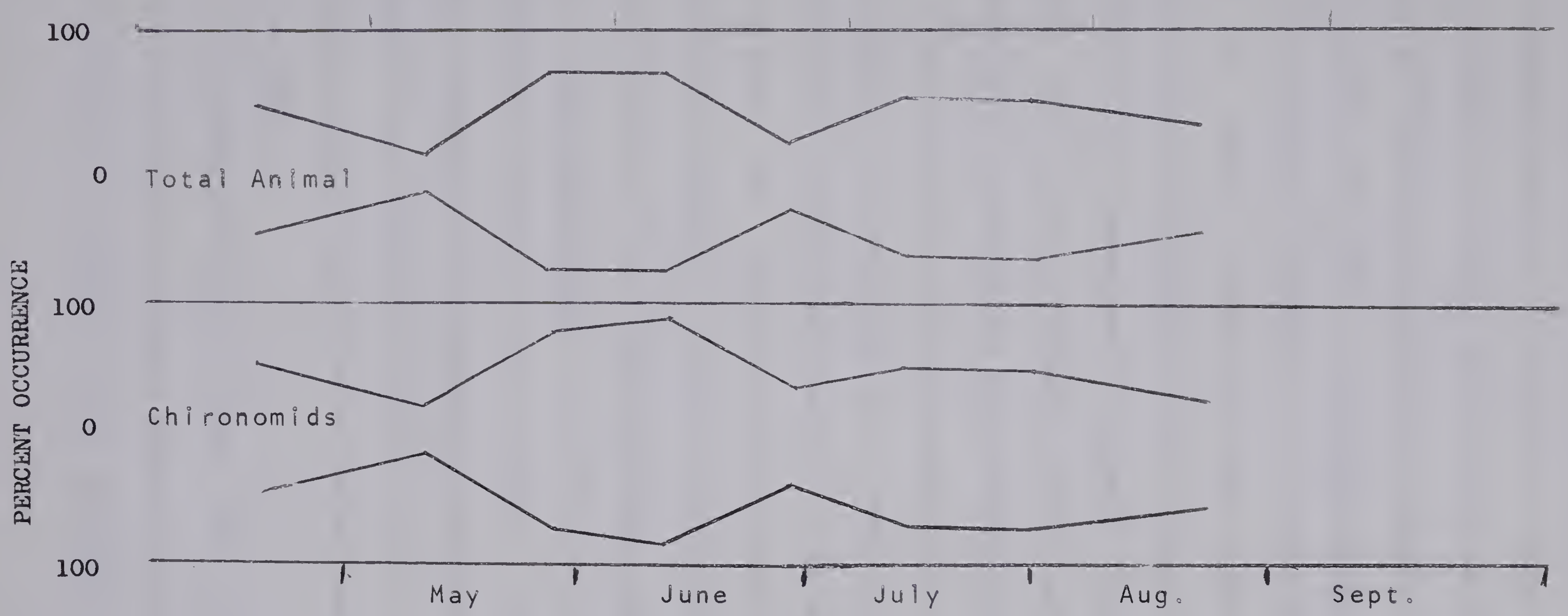


Figure 10. Seasonal variation in major food items in adult ruddy ducks (data for 1964 and 1965 pooled).



SEASONAL VARIATION IN HELMINTH POPULATIONS

Colbo (1965) recognized several patterns of seasonal variation in helminth populations based on extensity of infection. However, patterns of extensity alone do not always give accurate pictures of the seasonal distribution of helminths, especially for helminths which have a high extensity throughout the season. Polymorphus marilis is an excellent example. This helminth is present in all of the birds examined after June (Fig. 11). However, if one graphs median intensity times extensity, or the median number of helminths per bird, versus season, a distinct pattern, essentially a summer peak, is apparent (Fig. 12). For this reason median intensity times extensity will be used as the measure of the helminth population throughout the following discussion.

It was difficult to fit the seasonal patterns of most of the individual helminths of scaup (Fig. 12) or adult ruddies (Fig. 13) (the immature ruddies examined were too few to analyze) to the patterns described by Colbo, 1965. However, certain helminths did show some of the patterns Colbo described. A definite spring peak is apparent in three of the helminths of scaup (Echinoparyphium recurvatum, Dicranotaenia coronula, and Amidostomum acutum). A marked spring-fall peak is shown by Apatemon gracilis in scaup, but not in ruddies. A summer peak was observed for Diorchis excentricus and Epomidiostomum uncinatum in ruddies, and for all the gammarid-borne helminths analyzed in adult scaup. These gammarid-borne helminths gradually accumulate in immature scaup, reaching peak values in the fall.

As has been pointed out by Colbo (1965) and Buscher (1965), these seasonal variations in helminth populations are brought about by a complex of factors. A number of these, including seasonal variation

Figure 11. Seasonal variation in extensity of <u>Polymorphus marilis</u> in adult and immature lesser scaup.

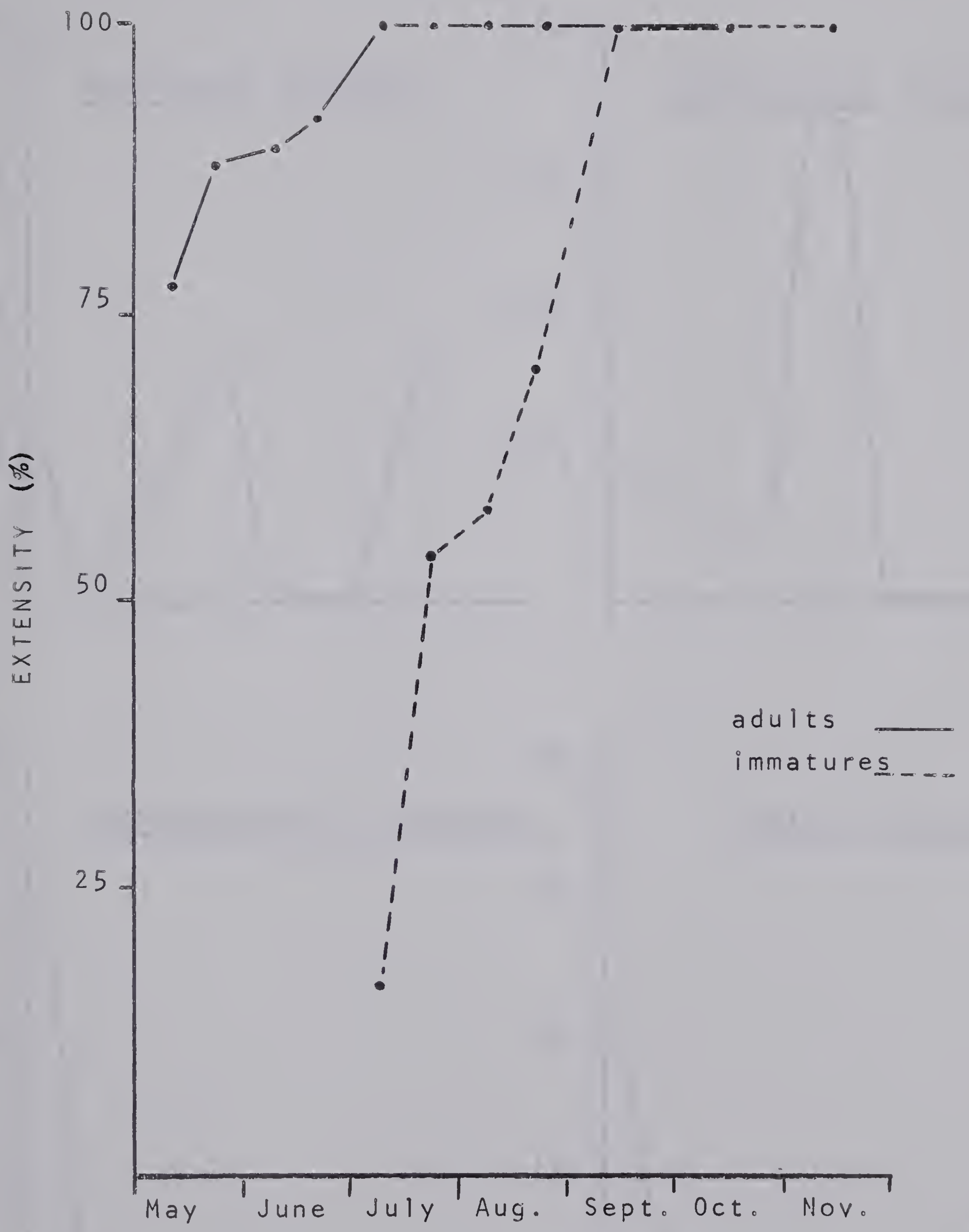


Figure 12. Seasonal variation of the major helminths of adult and immature lesser scaup.

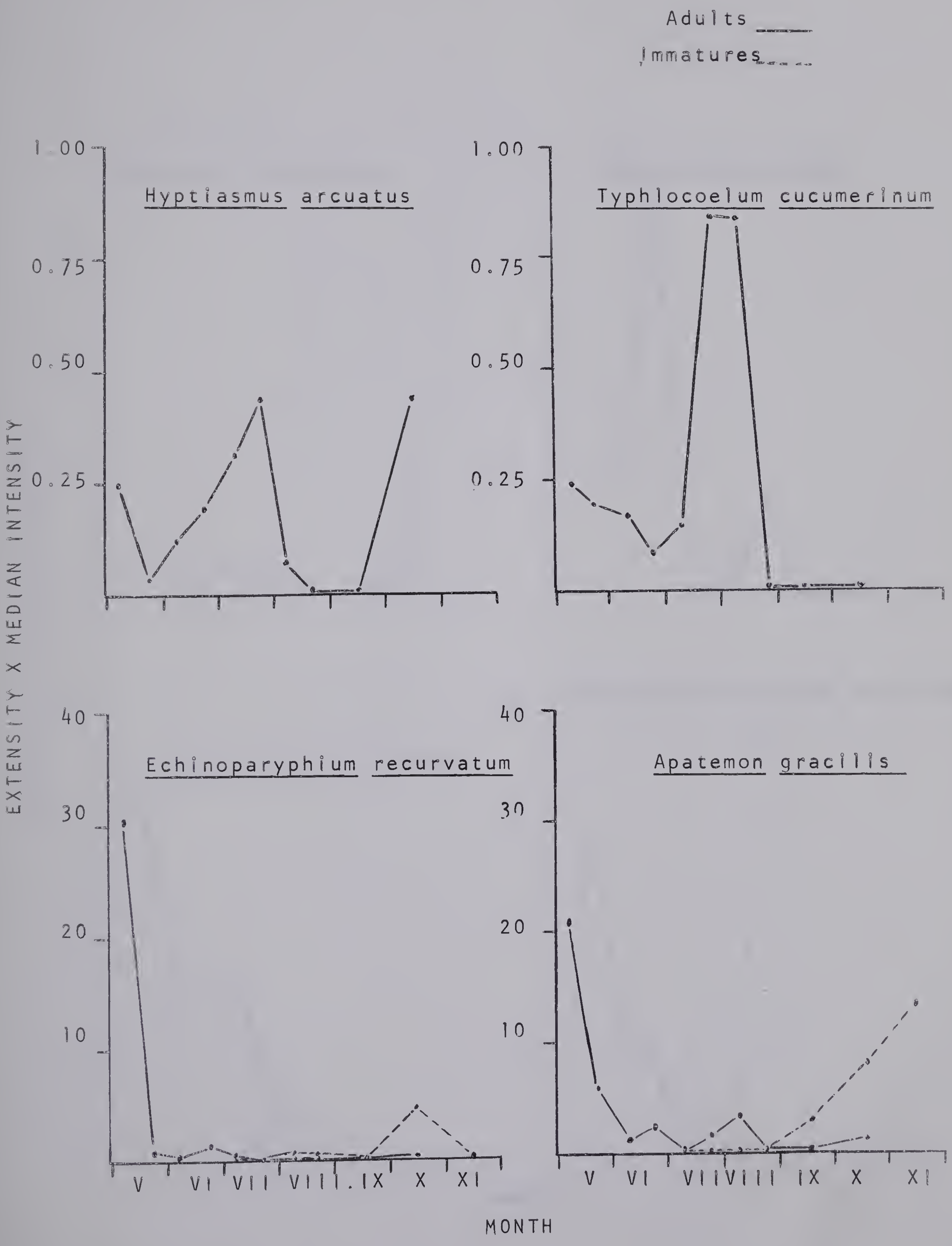


Figure 12 (continued)

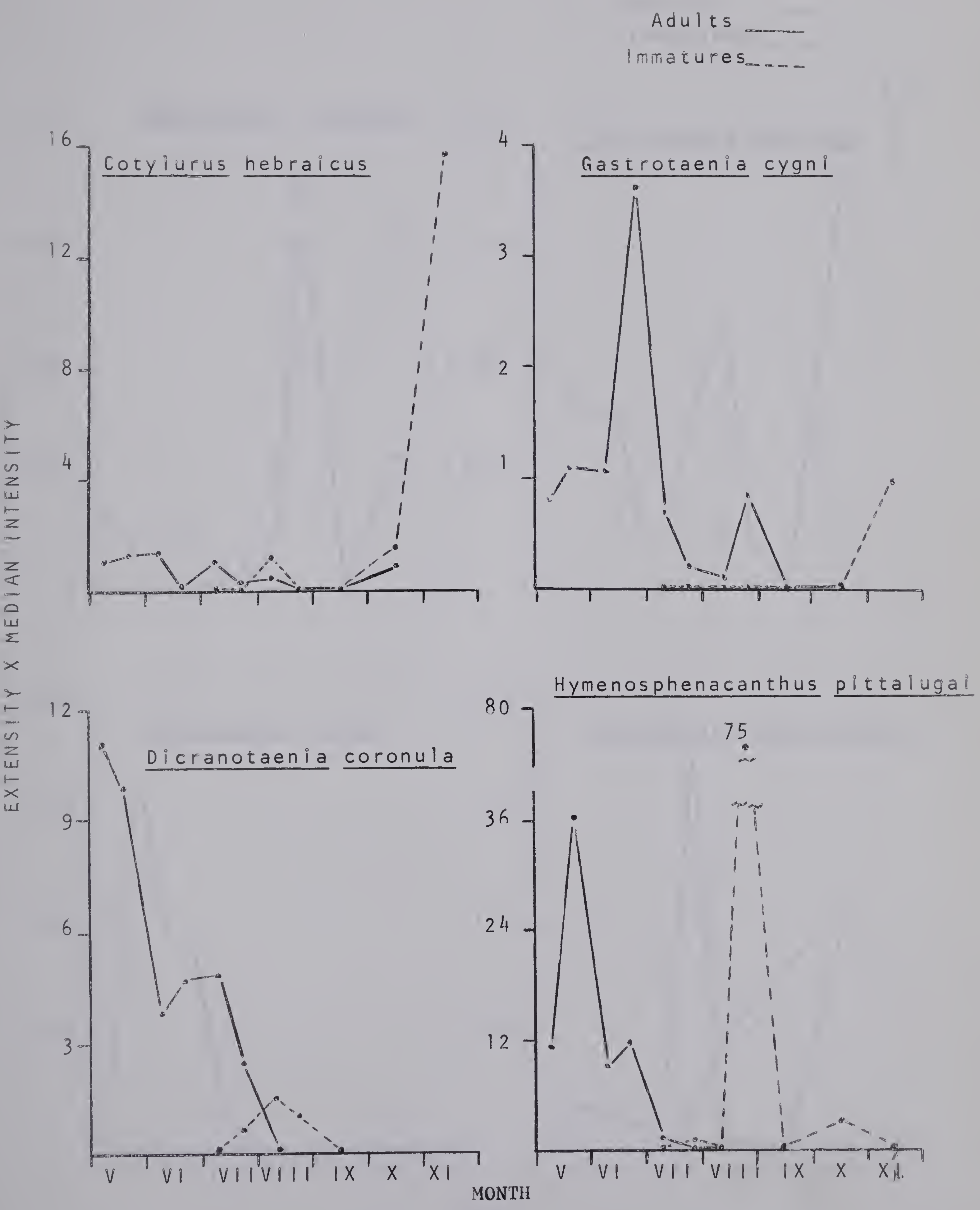


Figure 12 (continued)

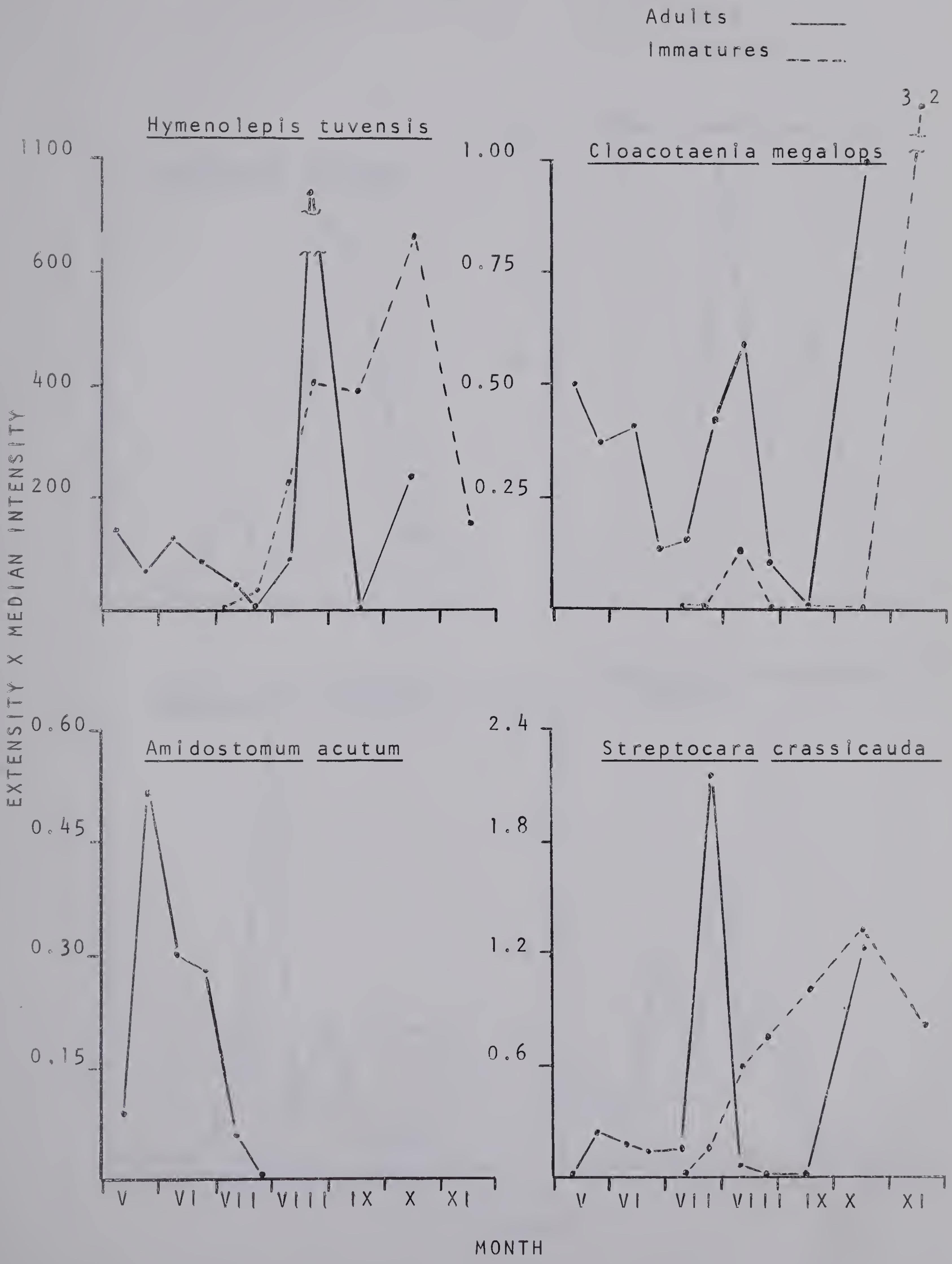


Figure 12 (continued)

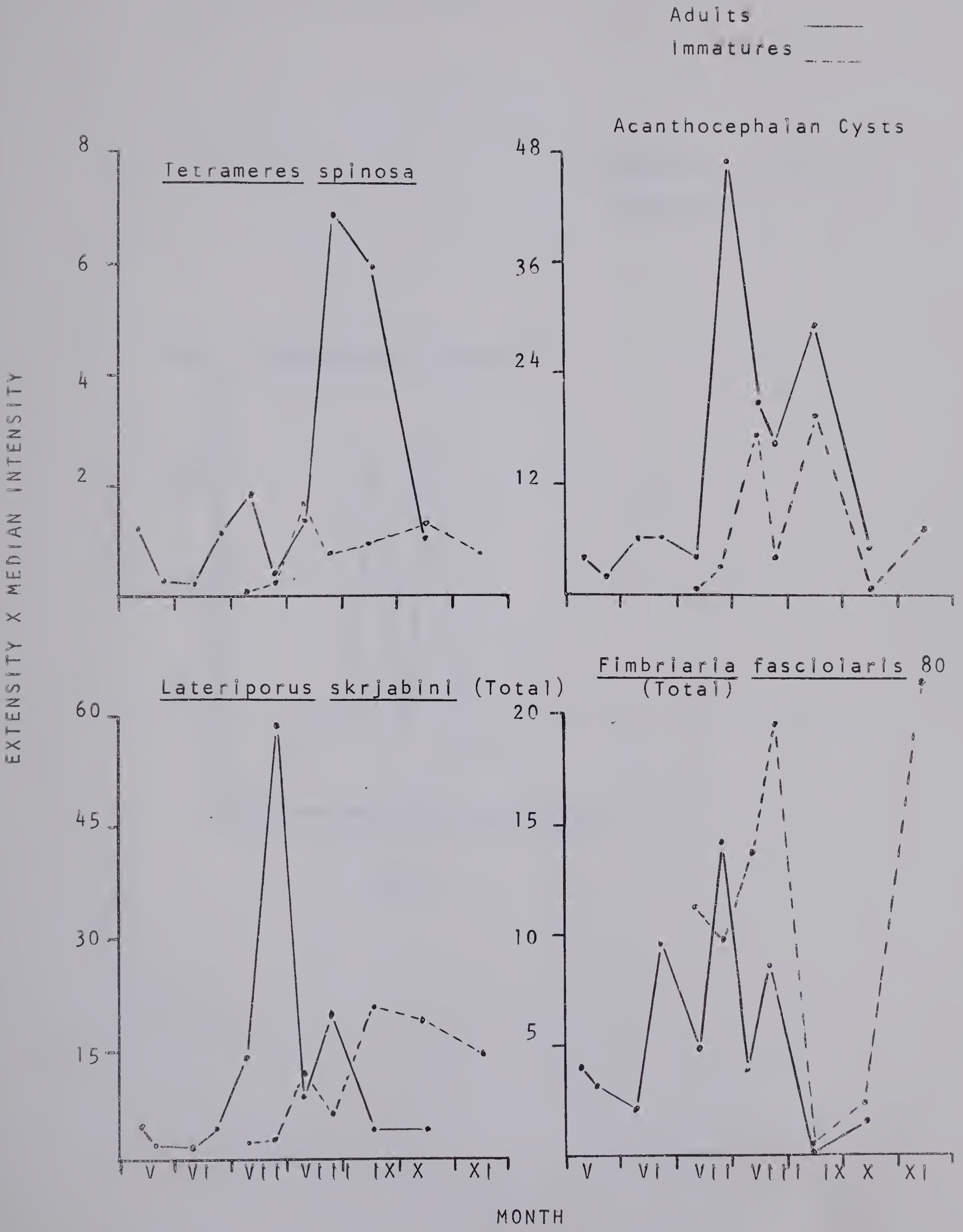


Figure 12 (continued)

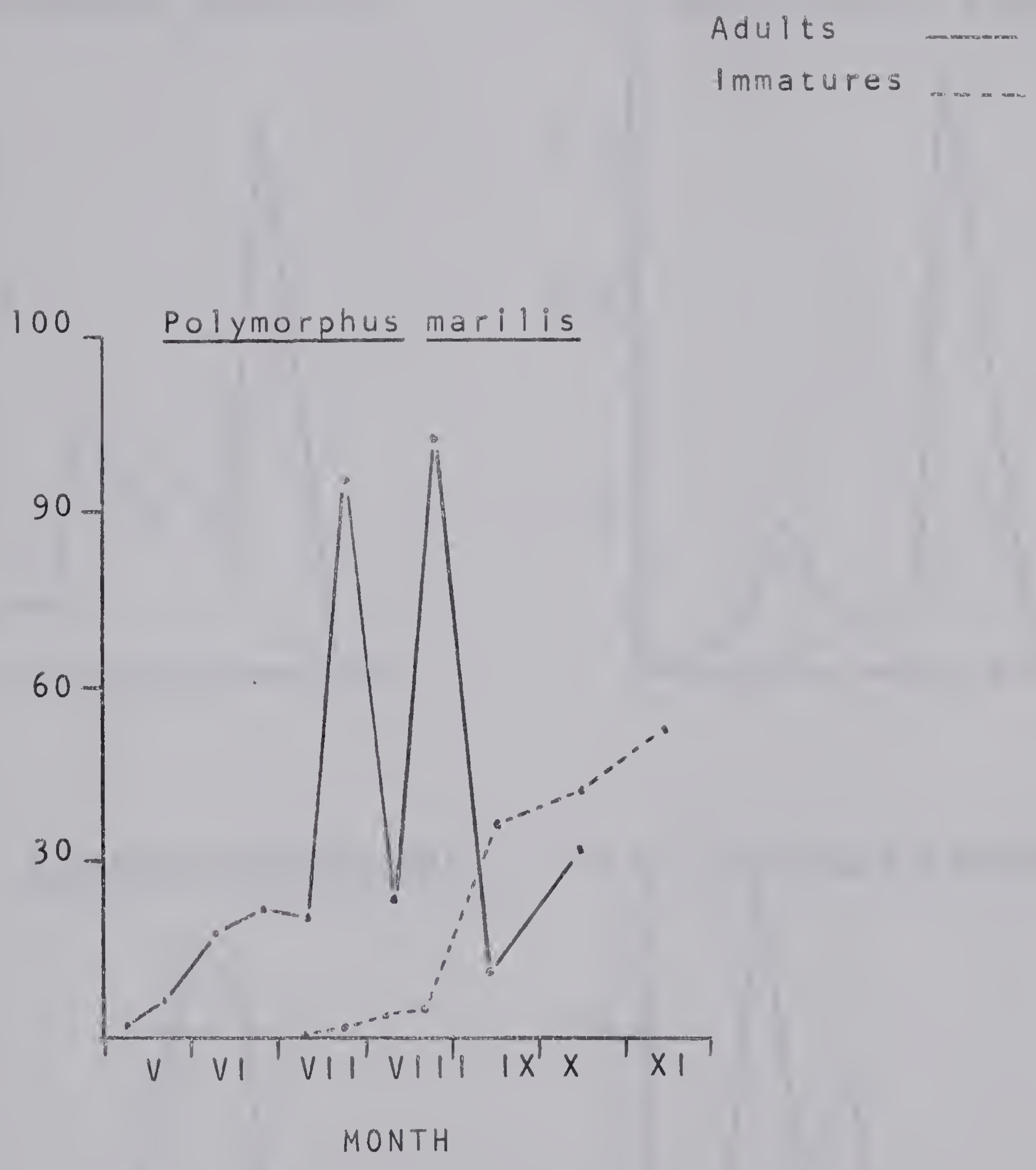


Figure 13. Seasonal variation of the major helminths of adult ruddy ducks.

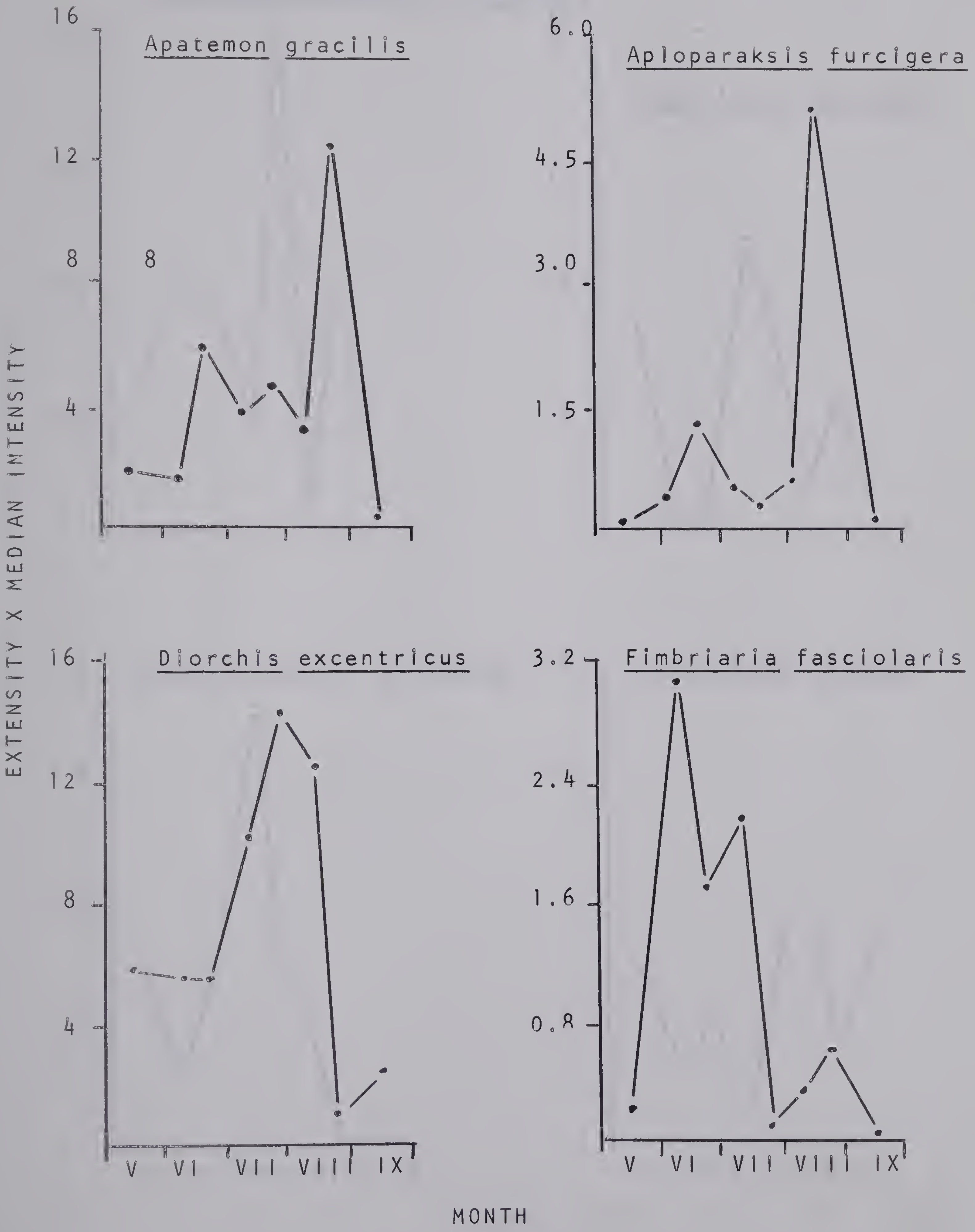


Figure 13 (continued)

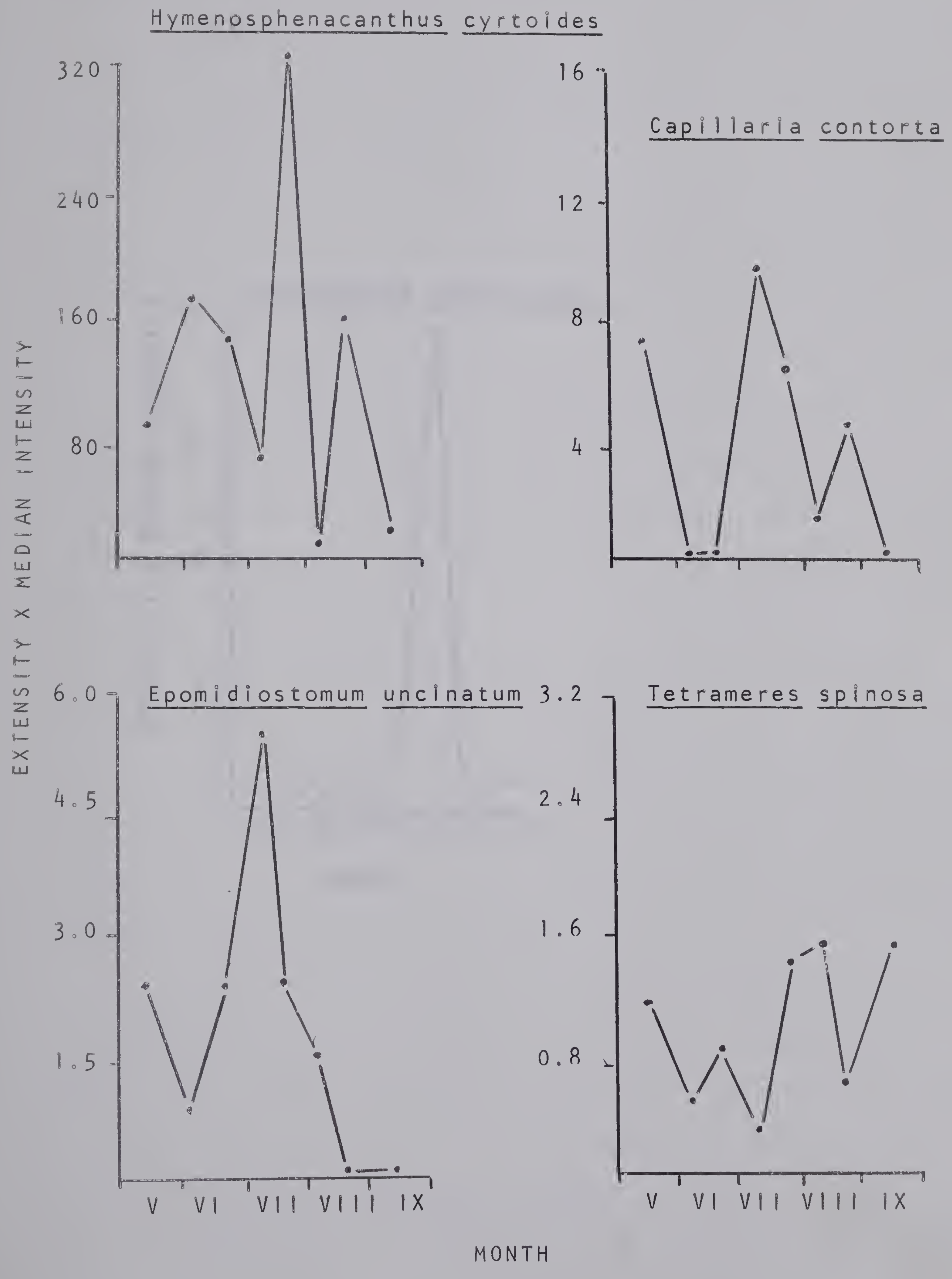
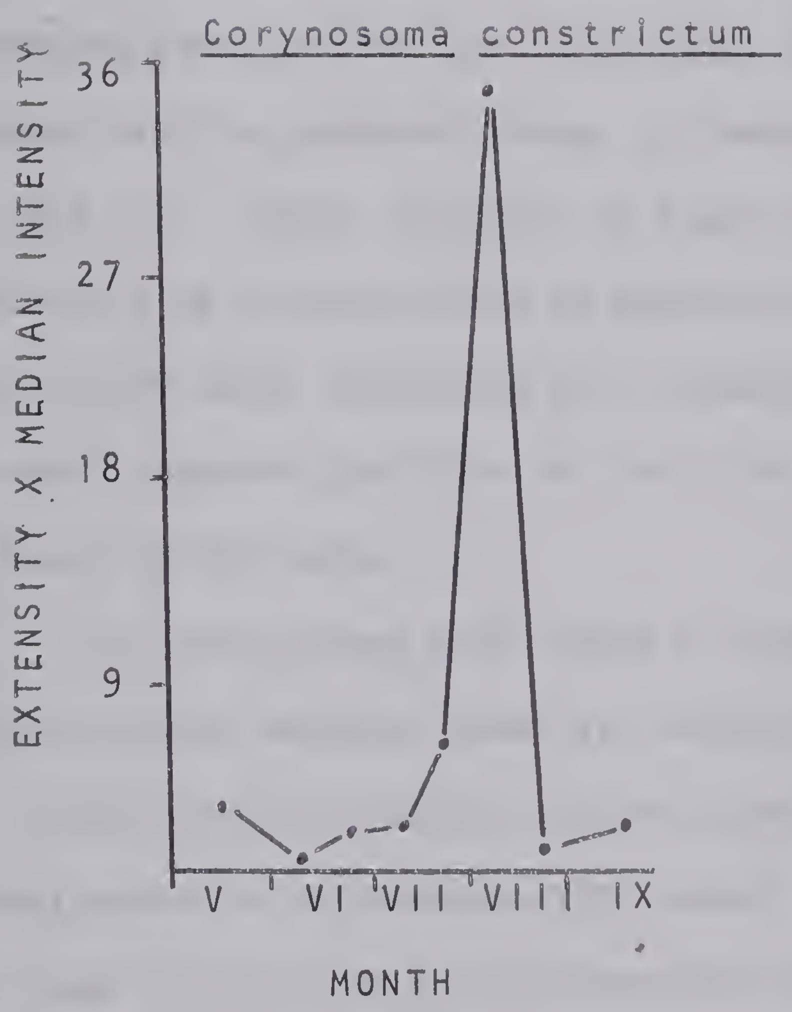


Figure 13 (continued)



in food habits, how the nucleus of a helminth population is provided in the spring, seasonal changes in the population structure or populations of the intermediate host, and competition between members of the bird's helminth community, appeared to be involved in this study.

Seasonal changes in food habits, as mentioned in the previous section, undoubtedly affect helminth populations. The major gammarid-borne parasites show a summer peak in infection in adult scaup (Fig. 14), which correlates with the preponderance of gammarids in summer food samples (Fig. 9). In addition, Apatemon gracilis, which has a leech intermediate host, shows a spring and fall distribution in scaup which correlates with the seasonal change in leeches in the food samples from scaup (Fig. 9). Scaup, according to Rogers and Korshgen, 1966, fed predominently on molluscs while in migratory congregations in Illinois. The relatively large infections with trematodes (Fig. 15) in the earliest scaup would indicate that this is also true for the populations of scaup which breed in this area.

The conclusions with regard to the seasonal food habits of ruddies and their helminth fauna are much harder to draw. The major animal food source for ruddies are chironomids, which have not as yet been implicated in any helminth life cycle. Still, the seasonal peak in animal food in August (Fig. 10) correlates with a seasonal peak in helminths in ruddies during the same period (Fig. 16).

The nucleus of a helminth population in a migratory bird on its breeding grounds can be provided in three ways. Buscher (1965) mentions two of these: helminths may be brought into the breeding area by the bird itself, or helminths may be brought in by some other bird and then transferred. Lateriporus skrjabini is brought in by scaup. The earliest scaup harbored infections of both mature and immature worms

Figure 14 Seasonal variation of the major gammarid-borne helminths of adult lesser scaup.

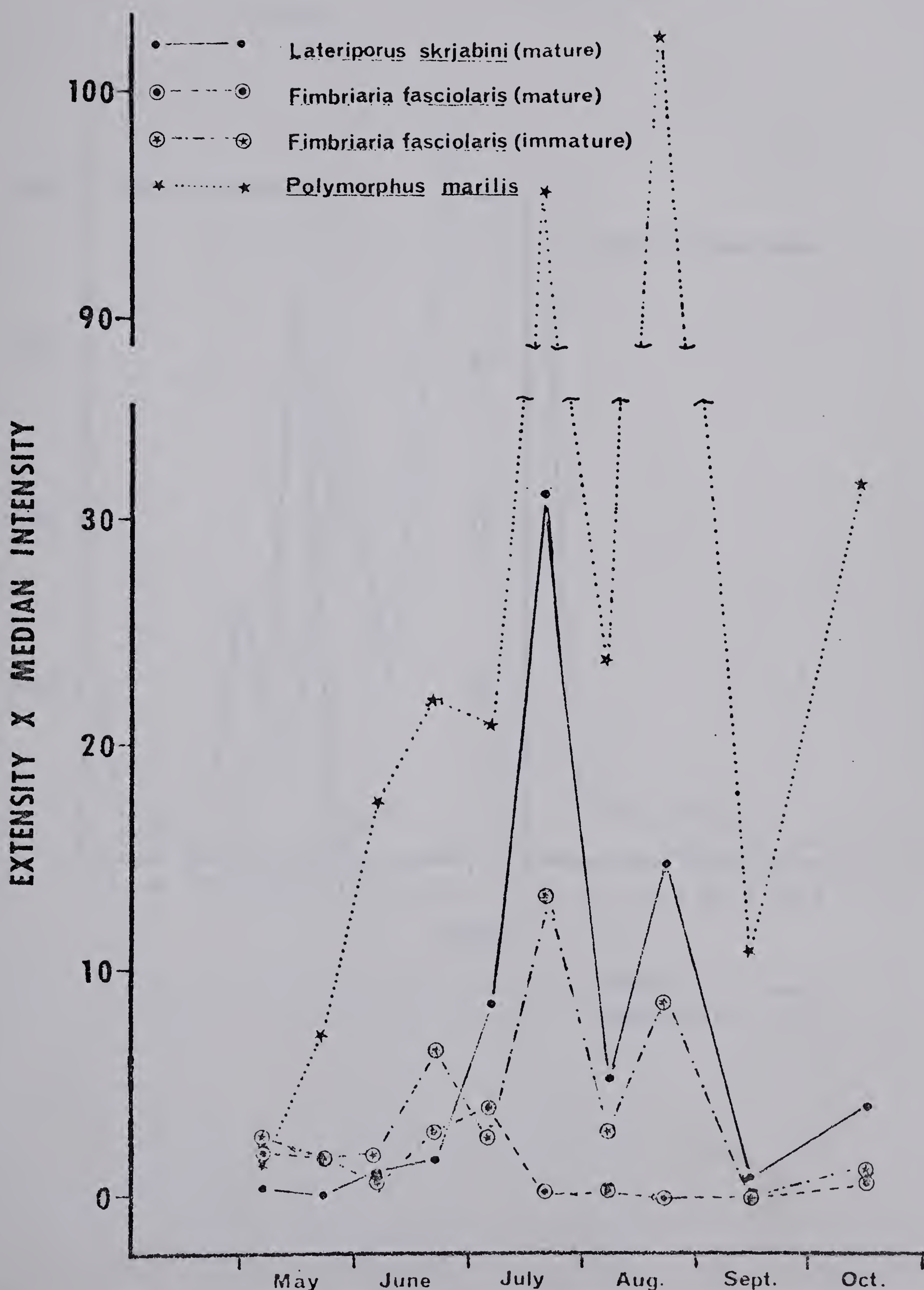


Figure 15. Seasonal variation of total trematodes and total cestodes in adult and immature lesser scaup.

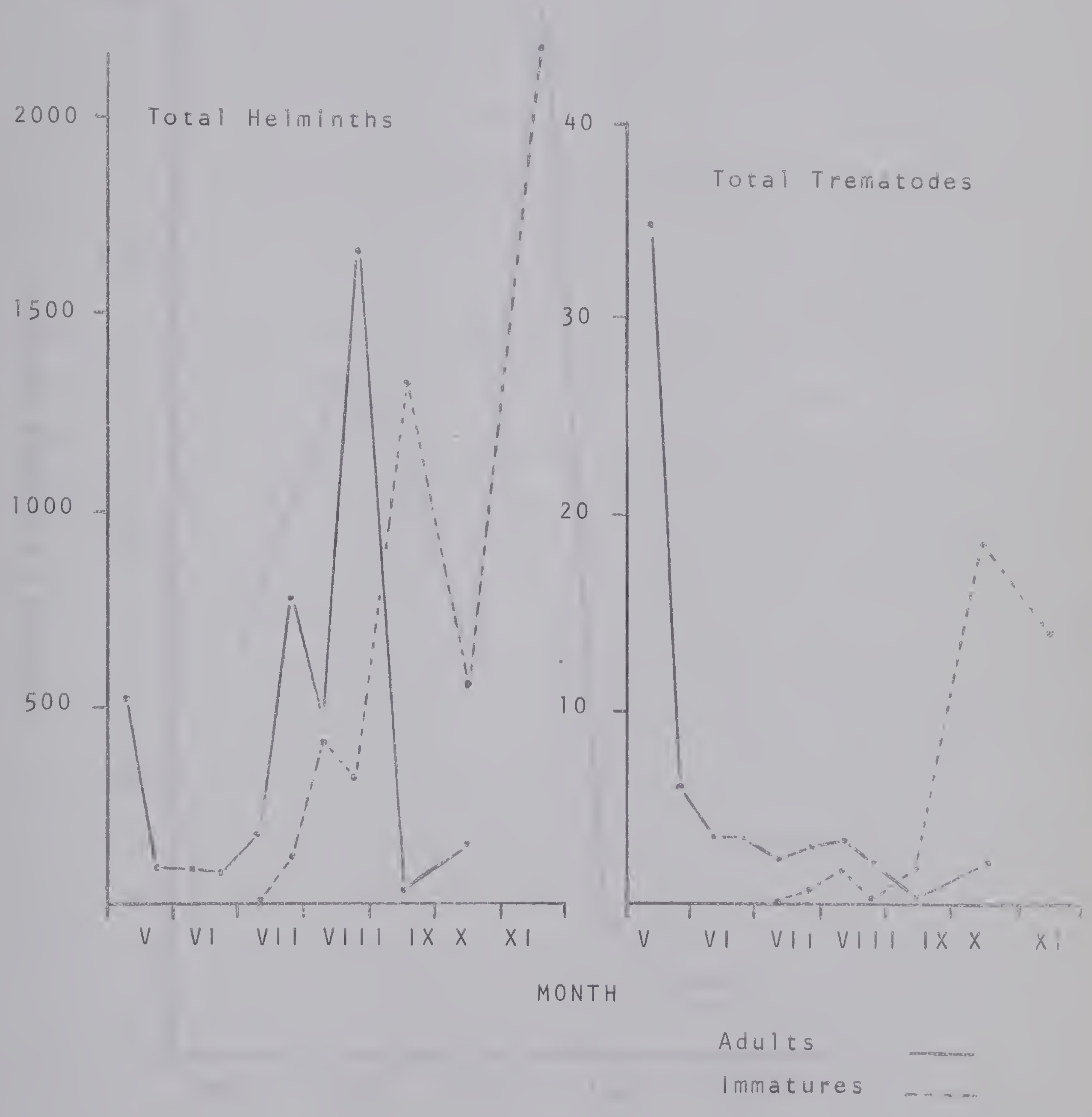
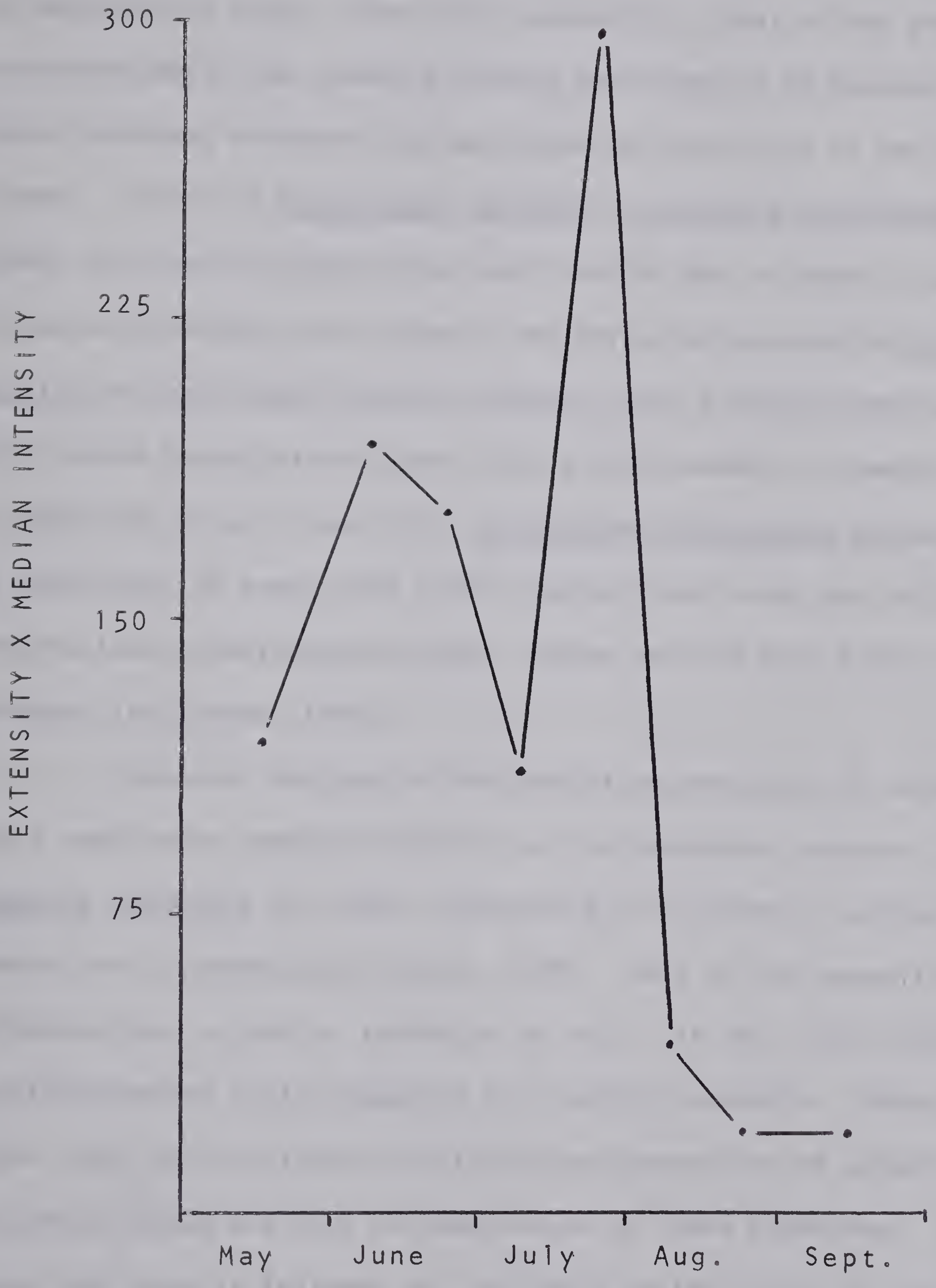


Figure 16. Seasonal variation in total helminths of adult ruddy ducks.



(Fig. 14); in addition, no cysts of _L. skrjabini_ were found by Mr. M. Denny or myself in several thousand gammarids collected from under the ice immediately before spring breakup. Helminths brought in by other birds and then transfered to scaup would include those which are accidental or inhibited in scaup. The third possibility, that of the parasite overwintering on the breeding grounds, was rejected by Buscher. However, there is direct evidence that helminths do overwinter on the breeding grounds. Cysts of _Polymorphus marilis_, _Streptocara crassicauda_ and a number of other helminths have been found by Mr. M. Denny in gammarids collected throughout the winter. The spring infections of _Polymorphus marilis_ in scaup gives further evidence, with a large proportion of the early scaup being infected, but with a small number of immature worms in each case (Fig. 11 and 12). _Streptocara crassicauda_ apparently builds up infections in some other birds (the earliest scaup had no _S. crassicauda_) and are then transferred to scaup. Grebes are the main hosts for this helminth (Gallimore, 1964).

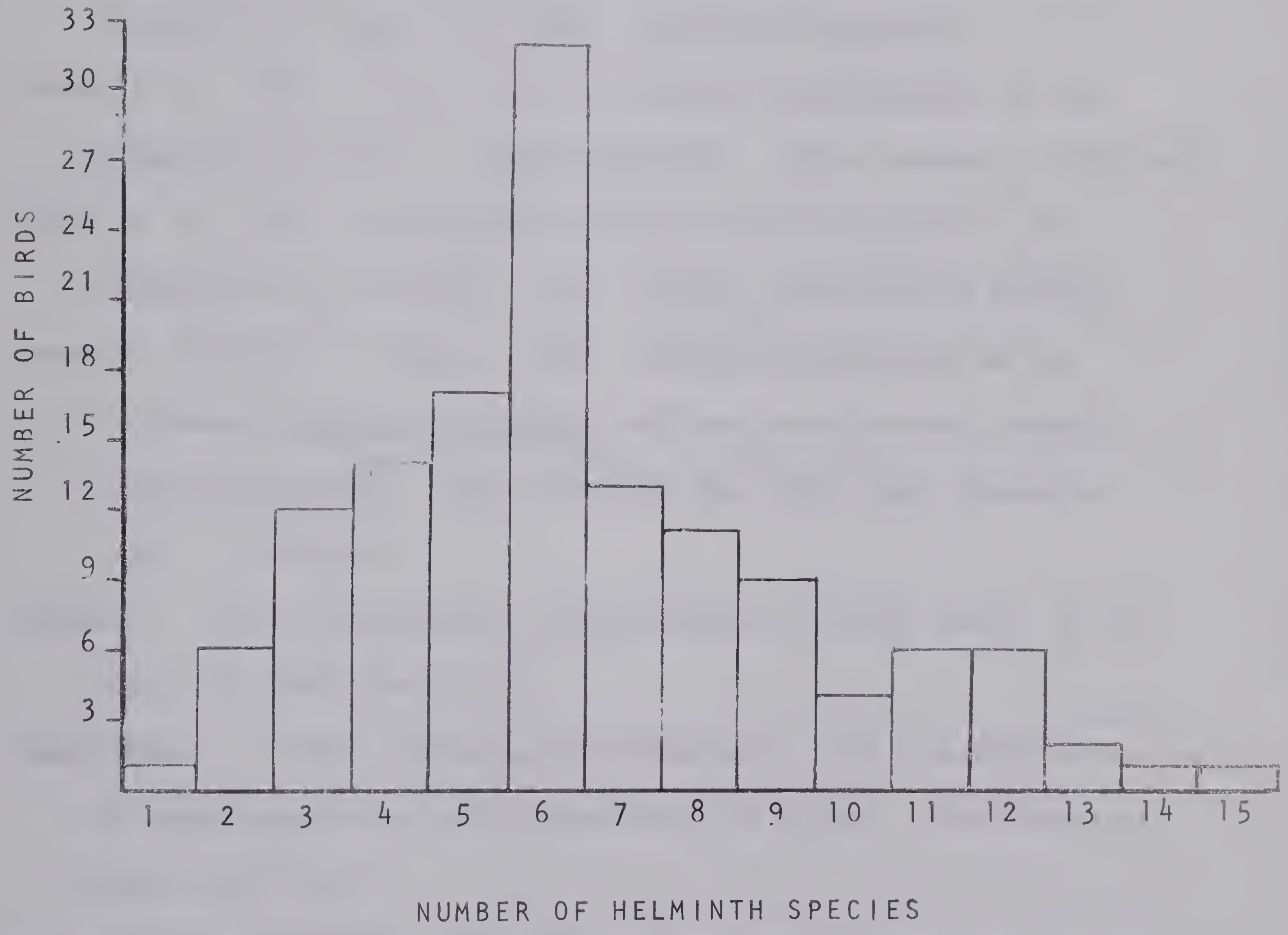
Seasonal changes in the population structure of intermediate hosts would have important effects on the helminths involved. Many adult _Gammarus lacustris_ die after reproducing in midsummer, leaving the new generation to predominate (Menon, 1966). Most of the gammarid-borne helminths show a peak of infection in July. At this time, moribund heavily-infected adult gammarids are readily available. Shortly thereafter, only the relatively uninfected new generation of gammarids are available, hence the drop in populations of these helminths. In most cases this drop is followed by a build-up as infections in the new generation of gammarids mature.

Seasonal distribution of the intermediate hosts may be responsible for patterns of infection such as one finds for _Dicranotaenia_

coronula (Fig. 12), which has various ostracods and copepods as intermediate hosts (Jarecka, 1961). It is unlikely that ducks feed specifically on these small crustaceans, but probably pick them up accidentally in the course of normal feeding. The spring and early summer distribution of D. coronula suggests that the major intermediate host in this area has a similar distribution. Buscher (1965) suggested a similar possibility in the spring distribution of Anomotaenia ciliata.

Multiple infections are common in scaup (Fig. 17), therefore the number of possibilities for interactions between helminths within an individual scaup is large. Although several cases of competition were suspected, only Fimbriaria fasciolaris and Lateriporus skrjabini gave clear indication of probable competition. Scaup are capable of harboring mature F. fasciolaris, yet after late June no mature F. fasciolaris were found, even though the ducks were still being exposed to new infections (Fig. 14). The drop in mature F. fasciolaris correlates well with the rise in mature L. skrjabini and both worms are found in the same region of the gut, suggesting that L. skrjabini prevents F. fasciolaris from maturing.

Figure 17. Occurrence of multiple infections in adult scaup.



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Appendix I. Seasonal distribution of major helminths in adult and immature lesser scaup.

Parasite	*Hyptiasmus arcuatus*				*Typhlocoelum cucumerinum*			
Host Age	Adult		Immature		Adult		Immature	
Date	Ext.	Intensity Md. (Range)	Ext.	Intensity Md. (Range)	Ext.	Intensity Md. (Range)	Ext.	Intensity Md. (Range)
May 1-15	16.6	1.5(1-2)			25.0	1.0(1)		
May 16-31	6.2	1.0(1)			18.7	1.0(1)		
June 1-15	5.8	2.0(2)			11.7	1.5(1-2)		
June 16-30	9.5	2.0(1-3)			9.5	1.0(1)		
July 1-15	10.5	3.0(1-5)	0		15.7	1.0(1-3)	0	
July 16-31	21.4	2.0(1-8)	0		14.2	6.0(2-10)	0	
Aug. 1-15	7.1	1.0(1)	0		7.1	12.0(12)	0	
Aug. 16-31	0		0		0		0	
Sept. 1-30	0		0		0		0	
Oct. 1-31	22.2	2 (1-3)	0		0		0	
Nov. 1-15			0				0	

Appendix I (continued)

Parasite	Echinoparyphium ?recurvatum				Apatemon gracilis			
Host Age	Adult		Immature		Adult		Immature	
	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity
Date		Md. (Range)		Md. (Range)		Md. (Range)		Md. (Range)
May 1-15	50.0	62(22-750)			58.3	37(4-450)		
May 16-31	43.7	2.0(1-6)			56.2	11(3-57)		
June 1-15	11.7	2.5(2-3)			64.7	2(1-24)		
June 16-30	23.8	5.0(1-23)			52.3	5(1-134)		
July 1-15	5.2	3.0(3)	0		15.7	5(2-16)	0	
July 16-31	7.1	1.0(1)	10.0	7 (5-9)	35.7	5(2-52)	0	
Aug. 1-15	7.1	1.0(1)	14.2	2 (2)	35.7	11(2-36)	0	
Aug. 16-31	0		0		22.2	1(1)	5.0	4.0(4)
Sept. 1-30	25.0	1.0(1)	0		0		25.0	8.0(8)
Oct. 1-31	11.1	4.0(4)	33.3	16 (16)	55.5	2 (1-4)	33.3	25.0(25)
Nov. 1-15			0				80.0	16.5(3-46)

Appendix I (continued)

Parasite	Cotylurus hebraicus				Lateriporus skrjabini (mature worms)			
Host Age	Adult		Immature		Adult		Immature	
	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity
Date		Md. (Range)		Md. (Range)		Md. (Range)		Md. (Range)
May 1-15	25.0	4.0(1-7)			25.0	2.0(1-4)		
May 16-31	25.0	5.0(2-14)			12.5	1.0(1)		
June 1-15	41.1	3.0(1-9)			29.3	2.0(1-3)		
June 16-30	14.2	1.0(1-4)			42.8	4.0(1-15)		
July 1-15	15.7	7.0(3-16)	0		63.1	13.5(2-89)	0	
July 16-31	14.2	9.0(8-10)	0		71.4	43.5(2-306)	30.0	14.0(2-31)
Aug. 1-15	35.7	2.0(1-16)	14.2	10.0(10)	57.1	9.0(2-111)	85.7	8.5(2-44)
Aug. 16-31	0		0		77.7	19.0(2-58)	75.0	6.0(1-1000)
Sept. 1-30	0		0		25.0	3.0(3)	100.0	19.0(6-28)
Oct. 1-31	22.2	4.5(2-7)	33.3	5.0(5)	44.4	8.5(5-25)	100.0	18.0(8-20)
Nov. 1-15			40.0	39.5(2-75)			100.0	14.0(2-19)

Appendix I (continued)

Parasite	Lateriporus skrjabini (Imm. worms)				Lateriporus skrjabini (total)			
Host Age	Adult		Immature		Adult		Immature	
	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity
Date		Md. (Range)		Md. (Range)		Md. (Range)		Md. (Range)
May 1-15	41.6	5.0(5-33)			50.0	7.0(2-33)		
May 15-31	12.5	5.0(3-7)			18.9	4.0(1-7)		
June 1-15	17.6	1.0(1-2)			41.1	2.0(1-4)		
June 16-30	47.6	7.5(1-21)			80.9	4.0(1-33)		
July 1-15	36.8	16.0(3-38)	16.6	3.5(1-6)	68.4	19.0(2-105)	16.6	3.5(1-6)
July 16-31	85.7	27.5(1-70)	50.0	2.5(1-13)	92.8	63.0(2-306)	70.0	2.5(1-34)
Aug. 1-15	50.0	11.5(1-77)	42.8	10.0(2-20)	78.7	10.0(1-188)	85.7	12.0(3-46)
Aug. 16-31	50.0	7.5(2-52)	30.0	1.5(1-7)	77.7	25.0(2-62)	90.0	5.5(1-1000)
Sept. 1-30	75.0	3.0(1-11)	25.0	2.0(2)	100.0	3.0(1-11)	100.0	20.0(6-28)
Oct. 1-31	33.3	2.0(2-4)	0		66.6	5.0(2-25)	100.0	18.0(8-20)
Nov. 1-15			40.0	5.0(4-6)			100.0	14.0(2-25)

Appendix I (continued)

Parasite	*Fimbriaria fasciolaris* (mature worms)				*Fimbriaria fasciolaris* (imm. worms)			
Host Age	Adult		Immature		Adult		Immature	
	Ext.	Intensity Md. (Range)	Ext.	Intensity Md. (Range)	Ext.	Intensity Md. (Range)	Ext.	Intensity Md. (Range)
May 1-15	33.0	5.5(1-7)			58.0	5.0(1-450)		
May 16-31	44.0	4.0(1-12)			75.0	2.5(1-148)		
June 1-15	12.0	1.0(1-2)			52.9	4.0(1-13)		
June 16-30	71.4	4.0(1-20)			66.6	10.0(2-25)		
July 1-15	36.0	11.0(1-22)	0		52.0	5.0(1-40)	16.6	68.5(1-136)
July 16-31	7.0	2.0(2)	10.0	13.0(9-17)	64.2	21.0(1-120)	40.0	15.5(2-48)
Aug. 1-15	7.0	2.0(2)	14.2	4.0(4)	28.5	11.0(2-189)	85.7	15.0(1-26)
Aug. 16-31	0		30.0	11.0(3-34)	77.7	11.0(1-160)	55.0	30.0(4-360)
Sept. 1-30	0		0		0		25.0	1.0(1)
Oct. 1-31	11.1	4.0(4)	33.3	7.0(7)	33.3	3.0(1-6)	0	
Nov. 1-15			50.0	39.5(4-73)			80.0	70.0(6-180)

Appendix I (continued)

Parasite	Fimbriaria fasciolaris (total)				Gastrotaenia cygni			
Host Age	Adult		Immature		Adult		Immature	
Date	Ext.	Intensity Md. (Range)	Ext.	Intensity Md. (Range)	Ext.	Intensity Md. (Range)	Ext.	Intensity Md. (Range)
May 1-15	66.6	6.0(1-456)			41.6	2.0(2-10)		
May 16-31	81.0	4.0(1-160)			56.2	2.0(1-10)		
June 1-15	52.9	4.0(1-14)			52.9	2.0(1-11)		
June 16-30	85.7	11.0(1-45)			52.3	7.0(1-20)		
July 1-15	84.2	5.5(1-40)	16.6	68.5(1-136)	21.0	3.5(2-11)	0	
July 16-31	64.2	22.0(1-120)	40.0	24.0(2-48)	7.1	3.0(3)	0	
Aug. 1-15	28.5	12.0(2-189)	85.7	16.0(1-26)	14.2	1.0(1)	0	
Aug. 16-31	77.7	11.0(1-660)	60.0	32.5(3-364)	22.2	4.0(3-5)	0	
Sept. 1-30	0		25.0	1.0(1)	0		0	
Oct. 1-31	44.4	3.5(1-6)	33.3	7.0(7)	0		0	
Nov. 1-15			80.0	99.5(24-180)			20.0	5.0(5)

Appendix I (continued)

Parasite	*Dicranotaenia coronula*				*Hymenosphenacanthus pittalugai*			
Host Age	Adult		Immature		Adult		Immature	
	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity
Date		Md. (Range)		Md. (Range)		Md. (Range)		Md. (Range)
May 1-15	58.3	18.0(5-125)			41.6	28.0(14-200)		
May 16-31	50.0	19.5(1-56)			25.0	146.0(6-280)		
June 1-15	52.9	7.0(1-36)			23.5	38.5(16-63)		
June 16-30	52.3	9.0(1-46)			19.0	58.5(12-305)		
July 1-15	36.8	13.0(1-28)	0		26.3	3.0(1-62)	0	
July 16-31	21.4	11.0(5-49)	10.0	5.5(1-10)	0		10.0	3.5(1-6)
Aug. 1-15	0		28.5	5.5(5-6)	7.1	1.0(1)	0	
Aug. 16-31	0		10.0	1.0(1)	0		5.0	1500.0(1500)
Sept. 1-30	0		0		0		0	
Oct. 1-31	0		0		0		33.3	9.0(9)
Nov. 1-15			0				0	

Appendix I (continued)

Parasite		*Hymenolepis tuvensis*				*Cloacotaenia megalops*		
Host Age		Adult		Immature		Adult		Immature
	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity
Date		Md. (Range)		Md. (Range)		Md. (Range)		Md. (Range)
May 1-15	58.3	270.0(24-3000)			25.0	2.0(2)		
May 16-31	81.2	91.0(3-750)			12.5	3.0(1-5)		
June 1-15	41.1	315.0(100-900)			11.7	3.5(1-6)		
June 16-30	47.6	190.0(1-1000)			9.5	1.5(1-2)		
July 1-15	63.1	77.5(3-460)	8.3	57.0(57)	10.5	1.5(1-2)	0	
July 16-31	42.8	5.5(2-7000)	55.0	70.0(16-1500)	21.4	2.0(1-3)	0	
Aug. 1-15	57.1	150.0(1-2800)	85.7	265.0(17-1800)	35.7	2.0(1-2)	14.2	1.0(1)
Aug. 16-31	66.6	1550.0(20-2300)	70.0	580.0(24-8000)	11.1	1.0(1)	0	
Sept. 1-30	25.0	1.0(1)	25.0	1600.0(1600)	0		0	
Oct. 1-31	44.4	765.0(13-3500)	66.6	1000.0(200-1800)	22.2	4.5(3-6)	0	
Nov. 1-15			20.0	800.0(800)			20.0	16.0(16)

Appendix I (continued)

Parasite	*Amidostomum acutum*				*Streptocara crassicauda*			
Host Age	Adult		Immature		Adult		Immature	
	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity
Date		Md. (Range)		Md. (Range)		Md. (Range)		Md. (Range)
May 1-15	8.3	1.0(1)			0			
May 16-31	25.0	2.0(1-14)			25.0	1.0(1-7)		
June 1-15	11.7	2.5(2-3)			17.6	1.0(1-2)		
June 16-30	9.5	3.0(2-4)			14.2	1.0(1-2)		
July 1-15	5.2	1.0(1)	0		15.7	1.0(1-4)	0	
July 16-31	0		0		21.4	10.0(1-14)	5.0	3.0(3)
Aug. 1-15	0		0		7.1	1.0(1)	28.0	2.0(1-3)
Aug. 16-31	0		0		0		25.0	3.0(1-4)
Sept. 1-30	0		0		0		50.0	2.0(1-3)
Oct. 1-31	0		0		11.1	11.0(11)	33.3	4.0(4)
Nov. 1-15			0				20.0	4.0(4)

Appendix I (continued)

Parasite	*Tetrameres spinosa*				*Polymorphus marilis*			
Host Age	Adult		Immature		Adult		Immature	
	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity
Date		Md. (Range)		Md. (Range)		Md. (Range)		Md. (Range)
May 1-15	33.3	3.5(1-6)			83.0	2.0(1-21)		
May 16-31	31.2	1.0(1-3)			87.0	8.5(2-82)		
June 1-15	35.2	5.0(1-20)			88.0	20.0(2-108)		
June 16-30	38.0	3.0(1-28)			92.2	24.0(2-111)		
July 1-15	47.3	4.0(1-12)	0		100.0	21.0(3-79)	16.6	1.5(1-2)
July 16-31	21.4	2.0(1-26)	10.0	3.0(3)	100.0	96.0(4-389)	55.0	4.0(1-12)
Aug. 1-15	57.1	2.5(1-10)	57.1	3.0(1-6)	100.0	24.0(4-148)	57.1	5.5(3-11)
Aug. 16-31	44.4	15.5(4-32)	25.0	3.0(1-4)	100.0	103.0(79-144)	70.0	7.5(1-65)
Sept. 1-30	25.0	24.0(24)	50.0	2.0(1-3)	100.0	11.0(5-52)	100.0	36.0(1-65)
Oct. 1-31	22.2	5.0(4-6)	33.3	4.0(4)	100.0	32.0(3-112)	100.0	42.0(16-156)
Nov. 1-15			20.0	4.0(4)			100.0	53.0(16-123)

Appendix I (continued)

Parasite	Acanthocephalan Cysts				Total Cestodes			
Host Age	Adult		Immature		Adult		Immature	
	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity
Date		Md. (Range)		Md. (Range)		Md. (Range)		Md. (Range)
May 1-15	16.6	20.5(3-38)			100.0	452.0(24-3555)	16.6	7.5(1-14)
May 16-31	25.0	7.5(5-60)			100.0	88.0(4-2402)	75.0	101.0(1-1527)
June 1-15	29.4	20.0(2-180)			100.0	79.0(3-2878)	100.0	392.0(24-788)
June 16-30	47.6	12.0(2-150)			100.0	78.0(4-12018)		
July 1-15	36.8	12.0(3-100)	25.0	1.0(1-3)	100.0	136.0(5-3914)	16.6	7.5(1-14)
July 16-31	100.0	47.5(3-312)	45.0	7.0(1-513)	100.0	267.0(10-7578)	75.0	101.0(1-1527)
Aug. 1-15	42.8	49.0(5-200)	85.7	20.0(6-103)	85.7	409.0(1-11210)	100.0	392.0(24-788)
Aug. 16-31	88.8	18.5(5-40)	50.0	7.5(5-40)	100.0	1260.0(3-2971)	95.0	325.0(3-8003)
Sept. 1-30	50.0	58.5(7-110)	25.0	78.0(78)	100.0	3.5(1-11)	100.0	1271.5(6-1626)
Oct. 1-31	44.4	12.5(4-13)	0		88.8	186.5(9-1529)	100.0	527.0(27-2808)
Nov. 1-15			60.0	12.0(3-43)			100.0	2130.0(49-9039)

Appendix I (continued)

Parasite	Total Trematodes				Total Nematodes			
Host Age	Adult		Immature		Adult		Immature	
	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity
Date		Md. (Range)		Md. (Range)		Md. (Range)		Md. (Range)
May 1-15	91.6	38.0(1-1253)			50.0	3.0(1-6)		
May 16-31	87.5	7.0(1-60)			56.2	3.0(1-14)		
June 1-15	76.4	5.0(1-37)			64.7	3.0(1-24)		
June 16-30	71.4	5.0(1-135)			47.6	3.5(1-28)		
July 1-15	78.5	3.0(1-18)	0		47.3	6.0(1-14)	0	
July 16-31	50.0	6.0(2-60)	20.0	3.0(1-9)	35.7	2.0(2-70)	15.0	3.0(1-8)
Aug. 1-15	64.2	5.0(1-53)	28.5	6.0(2-10)	64.2	1.0(1-10)	71.4	3.0(1-12)
Aug. 16-31	11.1	1.0(1)	5.0	4.0(4)	44.4	15.5(4-32)	45.0	5.0(2-24)
Sept. 1-30	25.0	1.0(1)	25.0	8.0(8)	25.0	24.0(24)	75.0	3.0(1-5)
Oct. 1-31	77.7	3.0(1-12)	33.3	56.0(56)	33.3	6.0(1-15)	33.3	6.0(6)
Nov. 1-15			80.0	17.5(4-121)			60.0	4.0(3-6)

Appendix I (continued)

Parasite	Total Acanthocephala				Total Helminths			
Host Age	Adult		Immature		Adult		Immature	
	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity
Date		Md. (Range)		Md. (Range)		Md. (Range)		Md. (Range)
May 1-15	91.6	1.0(1-15)			100.0	539.0(31-4810)		
May 16-31	87.5	8.5(2-82)			100.0	116.0(9-2464)		
June 1-15	88.2	27.0(2-108)			100.0	112.0(10-2948)		
June 16-30	100.0	24.0(2-111)			100.0	103.0(29-12065)		
July 1-15	100.0	21.0(3-79)	16.6	1.5(1-2)	100.0	166.0(30-2591)	20.0	8.0(1-412)
July 16-31	100.0	96.0(4-389)	55.0	4.0(1-12)	100.0	784.0(35-7714)	75.0	132.0(2-1541)
Aug. 1-15	100.0	24.0(4-174)	57.1	5.5(3-11)	100.0	465.0(9-11220)	100.0	402.0(26-941)
Aug. 16-31	100.0	103.0(79-144)	70.0	7.5(1-65)	100.0	1662.0(82-2467)	95.0	338.0(3-8017)
Sept. 1-30	100.0	11.0(5-52)	100.0	36.0(1-65)	100.0	22.5(15-63)	100.0	1337.0(15-1636)
Oct. 1-31	100.0	32.0(3-112)	100.0	42.0(16-156)	100.0	150.0(6-3624)	100.0	625.0(183-2830)
Nov. 1-15			100.0	53.0(16-123)			100.0	2180.0(18-9113)

Appendix II. Seasonal distribution of major helminths in adult ruddy ducks.

Parasite	*Apatemon gracilis*		*Fimbriaria fasciolaris*		*Aploparaksis furcigera*		*Diorchis excentricus*	
Host Age	Adult		Adult		Adult		Adult	
	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity
Date		Md. (Range)		Md. (Range)		Md. (Range)		Md. (Range)
May 1-31	46.0	4.0(1-18)	20.0	1.0(1-5)	0		73.0	8.0(1-47)
June 1-15	75.0	2.0(1-56)	66.6	4.5(1-11)	8.0	3.0(3)	66.6	8.0(2-57)
June 16-30	58.0	10.0(1-33)	41.0	4.0(2-14)	41.0	3.0(1-6)	83.0	6.5(1-63)
July 1-15	71.0	5.0(1-9)	71.0	3.0(1-5)	42.0	1.0(1-14)	100.0	10.0(4-66)
July 16-31	50.0	9.0(1-28)	10.0	1.0(1)	10.0	2.0(2)	70.0	20.0(1-120)
Aug. 1-15	66.6	4.5(2-54)	33.3	1.0(1)	50.0	1.0(1-6)	83.0	15.0(3-34)
Aug. 16-31	20.0	61.0(61)	20.0	3.0(3)	20.0	25.0(25)	20.0	5.0(5)
Sept. 1-30	0		0		0		50.0	5.0(5)

Appendix II (continued)

Parasite	*Hymenosphenacanthus cyrtoides*		*Capillaria contorta*		*Epomidiostomum uncinatum*		*Tetrameres spinosa*	
Host Age	Adult		Adult		Adult		Adult	
	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity
Date		Md. (Range)		Md. (Range)		Md. (Range)		Md. (Range)
May 1-31	80.0	112.0(5-2700)	26.0	28.0(2-33)	66.6	3.5(1-31)	13.0	8.5(2-17)
June 1-15	100.0	166.0(2-1640)	25.0	1.0(1-21)	33.3	2.5(1-6)	16.0	3.0(2-4)
June 16-30	83.0	172.5(27-550)	25.0	1.0(1-2)	58.0	4.0(1-45)	16.0	5.0(3-7)
July 1-15	85.0	77.0(34-1100)	42.0	23.0(2-28)	57.0	9.5(1-29)	14.0	2.0(2)
July 16-31	90.0	350.0(8-2000)	30.0	21.0(1-35)	30.0	8.0(5-11)	40.0	3.5(1-9)
Aug. 1-15	100.0	8.5(3-1400)	16.0	7.0(7)	50.0	3.0(2-9)	50.0	3.0(2-16)
Aug. 16-31	60.0	26.0(4-27)	40.0	11.0(6-16)	0		20.0	3.0(3)
Sept. 1-30	100.0	15.0(2-28)	0		0		50.0	3.0(3)

Appendix II (continued)

Parasite	*Corynosoma constrictum*		Total Cestodes		Total Trematodes		Total Nematodes	
Host Age	Adult		Adult		Adult		Adult	
	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity	Ext.	Intensity
Date		Md. (Range		Md. (Range)		Md. (Range)		Md. (Range)
May 1-31	46.0	7.0(1-47)	100.0	61.0(2-753)	60.0	4.0(1-21	80.0	6.0(1-64)
June 1-15	58.0	1.0(1-3)	100.0	163.0(4-1636)	75.0	4.0(1-56)	50.0	3.0(1-66)
June 16-30	58.0	2.0(1-12)	100.0	78.0(1-429)	75.0	4.0(1-48)	75.0	4.0(1-47)
July 1-15	57.0	3.0(1-5)	100.0	99.0(8-1171)	85.0	5.5(1-13)	71.0	31.0(1-36)
July 16-31	70.0	8.0(1-37)	100.0	278.0(12-2022)	70.0	12.0(1-49)	70.0	8.0(1-40)
Aug. 1-15	16.0	218.0(218)	100.0	26.5(4-1403)	83.0	7.0(1-54)	66.6	3.5(2-19)
Aug. 16-31	60.0	1.0(1-8)	80.0	15.5(4-55)	20.0	61.0(61)	40.0	12.5(9-16)
Sept. 1-30	100.0	1.5(1-2)	100.0	17.5(7-28)	0		50.0	3.0(3)

Appendix II (continued)

Parasite	Total Acanthocephala		Total Helminths	
Host Age	Adult		Adult	
	Ext.	Intensity	Ext.	Intensity
Date		Md. (Range)		Md. (Range)
May 1-31	46.0	7.0(1-47)	100.0	119.0(7-771)
June 1-15	58.0	1.0(1-3)	100.0	194.5(8-1675)
June 16-30	58.0	2.0(1-138)	100.0	177.0(6-588)
July 1-15	71.0	5.0(2-5)	100.0	111.1(38-1201)
July 16-31	90.0	3.0(1-37)	100.0	298.5(30-2050)
Aug. 1-15	16.0	218.0(218)	100.0	42.5(6-1629)
Aug. 16-31	60.0	1.0(1-8)	100.0	22.0(4-121)
Sept. 1-30	100.0	1.5(1-2)	100.0	20.5(12-29)